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Forthcoming Event.

SEPTEMBER 27—OCTOBER 1.
International Foundrymen's Congress and Exhibition at Detroit, U.S.A.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Meeting Current Problems.

Owing to the dispute in the coal-mining industry, foundries are being called upon to meet extraordinary metallurgical problems. This is a condition which will continue until the industry is definitely normal. Primarily, they bring home with unpleasant force the fact that foundry work is, after all, largely a metallurgical operation. Conditions are such that in many cases pig-iron of unknown quality has to be used, or in some cases it has to be entirely replaced by scrap and steel. If a foundry possesses a laboratory, the problem is half solved, as the nature of the new raw materials can be readily ascertained. They, at any rate, should need no advice from us. Where a foundry is in a position to carry on with unknown and untried pig-iron or cast-iron scrap, they would do well to call in an experienced metallurgist and provide for him some small but "chunky" steel scrap and the cheaper ferro-alloys. If high-class castings are to be made, the metallurgist can prepare from these ingredients a high-grade synthetic pig-iron which can be mixed with either domestic or bought scrap to produce castings of good quality.

Coke of doubtful quality can also be used to advantage where skilled metallurgical help is available. High ash content can be fluxed so as to render it harmless, whilst sulphur troubles can be largely neutralised by the addition of soda-ash briquettes. The control of a foundry when abnormal conditions prevail emphasises in the clearest possible way that "rule of thumb" has serious limitations. Under such conditions it either breaks down completely or involves heavy losses due to an augmentation in the waster bill at a time when trade can least afford it. If a foundry has orders, and material of an unknown or poor character with which to execute them, our advice is to engage a metallurgical chemist immediately, and if he cannot convert an existing room into a temporary laboratory and provide results within a fortnight he is not worth his salt. The modern chemist possesses his stock list for various sized laboratories. They merely need to be attached to the works official order book. He knows exactly the type of bench necessary, he is prepared for alternative systems of heating. He realises that whilst his laboratory is being prepared he can utilise outside laboratories, for, after all, the provision of a private workshop for a metallurgist is only done from a sense of economy and rapidity of service. The man who sets more store on his ability to provide correct analyses rather than on his ability to interpret these into useful industrial channels is not quite the type of man required by the foundry owner faced with the utilisation of uncertain raw materials. Whilst such uncertain conditions persist we are sufficiently optimistic to believe that it presents an excellent chance for the profitable collaboration of the enterprising foundry owner and the live metallurgist.

Jigger Hearth for Cast Iron.*

BY CARL IRRESBERGER (Salzburg).

The efforts to desulphurise cast iron suggested to Dr. Dechesne, of Rostock, the idea of trying to effect this by jigging and shaking the freshly-tapped metal. By jigging he understands the central shock which is primarily important for degasification, while by shaking he means the eccentric shock which causes violent wave-formation and effects a thorough intermixture. He was led to adopt this method by the well-known fact that on its way from the blast furnace to the foundry pig-iron loses a considerable portion of its sulphur content. This loss is directly noticeable by the strong smell of sulphur dioxide which generally accompanies the transporting vessels, but it has also been determined beyond all doubt by analytical tests of the metal at the blast furnace and in the foundry. A portion of the original sulphur content disappears even during tapping at the blast furnace, and this, too, is sensibly apparent by the distinct smell.

Opinions differ regarding the metallurgical principles underlying the desulphurisation of the metal which occurs during transport. While Osann ascribes it mainly to the thorough shaking up which the iron receives owing to the unavoidable jolting, Maierling and Dannecke take the view that it is merely due to the separation of the manganese combination. This latter theory is opposed by the fact that iron which for any reason cools in transporting vessels that are perperfectly still does not show any desulphurisation worth mentioning. For this reason some favourable influence on the desulphurisation, which unquestionably takes place, must certainly be attributed to the shaking. Such an influence, moreover, may very well be conceived on metallurgical grounds. The sulphur in cast iron is combined in the form of simple sulphide with manganese and iron. Owing to the greater affinity to manganese the preponderating amount of sulphur ought to be combined with the manganese, so that iron sulphide only occurs after saturation of the manganese. Manganese sulphide has a specific gravity of 3.6 to 4, and melts only at about 1,600 deg. C. With the temperatures here in question, therefore, which exceed 1,400 deg. only exceptionally, it is already present in a solid state, and owing to its slight weight it tries to make its way to the surface of the iron bath. The ascent of the manganese sulphide only comes to an end if the bath becomes too viscous owing to the temperature falling. It cannot be a matter of indifference whether, until this state begins, the iron is in a condition of perfect rest or of violent movement. As in every liquid, the violent commotion of confined constituents is caused by shaking, here also a thorough stirring up and intermixture of all the solid and liquid constituents takes place, whereby it is made easier for the specifically lighter portions to reach the surface. There the manganese sulphide burns according to the formula:—

$$MnS + 3O = MnO + SO_2.$$

The manganese oxide passes over into the slag, while the sulphur dioxide is volatilised. The jigging experiments carried out at the Deutsche Industriewerke have entirely confirmed these hypotheses. It was found possible to obtain a sulphur reduction up to 55 per cent., while the ascent of the sulphur was confirmed by the high sulphur content, rising to as much as 0.5 per cent., beneath the surface of the bath. There can scarcely be any doubt that by simultaneously maintaining the heat of the metal artificially its sulphur content can be reduced still lower.

The question of desulphurisation, however, passed into the background when it was recognised what much more important general improvements could be obtained by jigging the liquid iron—improvements which render even a relatively high sulphur content innocuous.

The known improvement processes in liquid iron are based upon superheating to high temperatures, or upon the lengthy maintenance of a good casting temperature, whether before or after casting. According to Piwowarsky, all pig- or cast-iron possesses, according to its chemical composition, a particular critical temperature, and on this temperature being exceeded it has the increasing tendency to solidify grey. This grey solidification must be attributable to two parallel processes; a solution of graphite particles still present, and the dissociation of carbide molecules. Undissolved graphite operates as a nucleus for the formation of coarsely laminated precipitations, which affect the structure detrimentally, and it is, therefore, unquestionably a harmful constituent. The two processes mentioned—the solution of the graphite and the decomposition of the carbide—ought to be attainable with thorough jigging while maintaining a good casting temperature. This is confirmed by the character of the grey iron influenced by jigging. Its structure consists of pearlitic basic material with eutectic graphite; ferrite, cementite and—with iron rich in phosphorus—steadite also appears.

Characteristic of the effects of jigging is the possibility of very liberal steel additions without endangering the casting capabilities owing to viscousness, without risk of piping and without tendency to white solidification. There is as yet no perfect certainty regarding the processes in the solidifying iron which lead to such results, and only conjectures and hypotheses are possible. But the material improvement of all the technical properties of the metal, as a result of thorough jigging while maintaining the initial temperature, is certain. Whether the iron contains 1.6 or 2.6 per cent. Si, 3.2 or 3.6 C, the following figures are obtainable with the normal casting temperature of 1,350 to 1,400 deg. C.: tensile

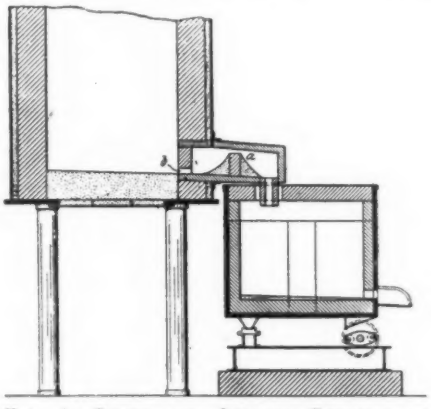


FIG. 1.—JIGGER AND SHAKING RECEIVER IN SECTION (DECHESNE TYPE).

strengths of 30 to 40 kg/mm.², bending strengths of 50 to 60 kg/mm.² and 15 mm. deflection with test pieces 30 mm. in diameter, the distance between supports being 600 mm., and in bars 15 mm. in diameter under the same conditions strengths up to 115 kg/mm.² with 25 mm. deflection. The Brinell hardness ranges between 180 and 240. These figures were obtained both with wet and dry castings.

Jigged iron solidifies in the very thinnest sections, and can be worked all over with the file. The ribs of air-cooled motor-bicycle cylinders, for example, which, even when iron almost free from sulphur is cast, too readily come from the Wuest furnace brittle and white, remain reliably grey, tough and workable by the file when metal subjected to the jigging process is employed. A special advantage of jigged iron consists in its very thorough degasification, which makes it much less liable to shrinkage, porosity and piping.

It is not merely jigged iron, however, that is found to stand large steel additions; liquid steel also can be favourably influenced, particularly by being considerably deoxidised and degasified. It will consequently be possible to produce ingots free from pipes with greater certainty than hitherto, and in the production of cast steel it will also be possible to employ the jigging process with material advantage.

A jigger hearth of this description is in operation at the Industriewerke in Spandau. It is constructed of cast-iron plates; only the bottom plate, which is directly exposed to the jigging impacts, is of cast steel. The front of the hearth is raised about 4 cm. by cam discs.

* "Stahl and Eisen," June 30, 1926.

The power is supplied by a 5-h.p. motor, which works on the jigger shaft by means of a worm gear with a 36:1 ratio. The number of revolutions can be regulated. With cast iron the practice is to work exclusively with 100 shocks per minute, as this number has been found most effective.

Fig. 1 shows a section through the lower part of the cupola and the jigger hearth. The special inlet gutter, which, like the jigger hearth, is patented, can also be seen. It is connected to the cupola furnace only by the narrow passage *b*, which, in common with the bridge at *a*, prevents the entrance of slag into the jigger hearth. The slag is from time to time tapped in the usual manner.

Originally efforts were made to pack the hearth opening with asbestos against the inlet gutter. The results were not successful, for asbestos becomes so friable even at a temperature of 900 deg. C. that no effective packing was possible. When it was apparent that the degasification was much better effected with an open hearth, all idea of packing was abandoned. The surface of the iron bath is, however, completely shut off from the blast pressure in the furnace and remains only under atmospheric pressure.

Before blowing in the furnace the inlet pipe to the receiver is closed and a portion of the gas generated by the combustion of the heating coke is admitted through a supply pipe to the receiver, from which it escapes to the open through the tap hole, the inspection hole, and other openings provided for the purpose. As soon as the first metal appears after starting the blast in front of the tuyeres, the gas supply pipe is closed, the inlet pipe is opened, and after the appearance of the first iron in the hearth the tap hole is closed. With this treatment the receiver is heated to nearly 1,200 deg. C., so that the iron flowing in is not cooled to any appreciable extent. Immediately after the tap hole is closed the jigging is begun, and this is continued until the receiver is full enough to be tapped.

The jigger hearth, therefore, requires no more attendance than an ordinary receiver. The tapper has merely to operate the switch lever of the motor at the proper moment. At present the cost of current at Spandau is only from 3 to 5 pfennigs per ton of jigged metal, a figure hardly worth considering.

Southern Foundries Close Down.

We regret to announce that, after a period of great activity, during which numerous other concerns have been compelled to suspend operations completely or else continue on part time only, the Southern Foundries, at Waddon, Croydon, one of the largest and most up-to-date foundries in the Southern Counties, have at last come to the end of their resources in regard to pig-iron, coke and other essential raw materials, and consequently the foundries have had to be closed indefinitely, thereby throwing a very large body of men out of employment.

For several weeks the management have been economising their valuable stocks of iron and coke by utilising a much larger proportion of scrap in the cupola, but it has now been found impossible to continue operations in face of the adverse conditions brought about by the continuance of the coal strike. It is exceedingly unfortunate for Major Small, Commander Withers, and the energetic management, who have the splendid record of keeping their works in practically full operation during the whole period of the general strike, that they should now find their activities curtailed by circumstances over which they have no control, and they are to be congratulated for making such a splendid fight in these most trying circumstances.

Even allowing for an early termination of the coal trouble, some weeks must elapse before operations can be resumed on anything approaching the recent scale.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In reply to Mr. Dawson's letter published in THE FOUNDRY TRADE JOURNAL of July 15 concerning our Paper entitled "Some Notes on the Chemistry of the Cupola," we should like to thank Mr. Dawson for communicating particulars regarding the very interesting series of cupola tests.

With regard to the amount of air which should be blown into the cupola, it is very satisfactory to note that the conclusions derived from theoretical considerations in the Paper are now confirmed by actual measurement. It may be mentioned that even the lowest volume tried (164 cub. ft. of air per lb. of coke) is slightly in excess of that required to burn the carbon in the coke completely to CO_2. Assuming that the measured blast volumes are correct both relatively and actually, it would therefore seem that from the point of view of fuel economy a further reduction in the air to, say, 155 cub. ft. per lb. of coke might have been made without interfering with the gratifying low-rejection percentage already reached.

It will be seen that the iron to coke ratio was really a second variable in these tests, and one might therefore ask to what extent, if any, the improved qualities of iron tapped were due to the decrease in this ratio. Need the iron to coke ratio have been reduced as low as 10.5? Mr. Dawson does not quote the temperature or composition of the escaping gases, but a reference to Fig. 2 of the Paper shows that theoretically, if the assumed constants are reliable, a ratio of 10.5 would be obtained with gases leaving the top of the charge at, say, 600 deg. C. and containing $CO:CO_2$ in the proportion 2:1 by volume. Allowing for the nitrogen present, the latter is equivalent to a waste gas consumption approximately:—CO, 18 per cent.; CO_2, 9 per cent.; N_2, 73 per cent. Averaged over a seven-hour blow, smaller heat losses than these might be expected with a well-designed cupola, and this suggests the possibility of increasing the iron to coke ratio to 12. This would give about 31,000 cub. ft. of air per ton of metal, which appears to be a figure obtainable in practice.

Mr. Dawson's method of judging overall efficiency by measuring the percentage of wasters is excellent where it can be applied, and the results obtained show how profitable systematic experiment in cupola practice may be.—Yours, etc.,

F. C. THOMPSON.
M. L. BECKER.

Department of Metallurgy,
The Victoria University of Manchester.
July 16, 1926.

A New Foundry Concern.

Messrs. Rubery Owen Foundries, Limited, of Willenhall, have recently put into commission a new iron foundry which is to cater for the requirements of the automobile industry. Mr. A. E. Owen is the chairman of the new company, and he has associated with him on the board Mr. L. O. Smith (managing), Mr. D. C. Lloyd, and Mr. F. Clough (technical). Mr. John Ayres has been appointed general manager and Mr. David Cartwright the foundry manager. In order to make known the advent of the new company a striking series of mailing cards has been circularised to the automobile industry.

THE CONSETT IRON COMPANY, LIMITED, Consett, Co. Durham, are still working some of their blast furnaces, and are in a position to make hematite and foundry irons. Moreover, the company have still some stocks of these to dispose of, and, with things so difficult as they are at present, it should be helpful to our foundry readers to know this.

XUM

The Institute of British Foundrymen.

BIRMINGHAM, COVENTRY AND WEST MIDLANDS BRANCH.

Following the annual meeting of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, held on the 29th ult., Mr. J. G. Pearce, B.Sc. (Director and Secretary of the British Cast Iron Research Association) contributed a Paper in which he discussed Recent Developments in Cast Iron Production. In the manufacture of modern castings, he said, especially for engineering purposes, the founder kept two main requirements in mind. In the first place, the metal required must have good mechanical properties, and secondly, it must be such as to enable the founder to get sound castings free from porosity and shrinkage defects. In the production of high quality irons the silicon content was usually arranged for a given thickness, so that the metal did not graphitise beyond the pearlite stage. This meant that the combined carbon content in the final casting was of the order of 0.7 per cent. to 0.9 per cent. In order to prevent the presence of the weakening graphite, the total carbon was kept as low as possible, the amount of graphite present being the difference between the total carbon and the 0.9 per cent. combined carbon; hence the lower the total carbon the lower the graphite. The phosphide eutectic must also be kept to a minimum, and in some irons it practically disappeared altogether. Such irons were, of course, very difficult to cast sound, and greater fluidity was assured without much danger if the phosphorus was retained at 0.2 to 0.4 per cent. There was no particular harm in the presence of sulphur, say up to 0.1 per cent., provided the manganese was of the order of 1 per cent., as with excess of manganese the sulphur took the form of small particles of comparatively harmless manganese sulphide. The tendencies towards improved cast irons from the point of view of composition were therefore apparent. They consisted mainly in a lowering of total carbon, silicon and phosphorus. If the reduction in total carbon was carried too far the ironfounder was confronted with many of the defects of steel founding. Furthermore, it was very desirable to maintain a correct relationship between carbon and silicon, although further research was required before the theoretically proper relationship could be demonstrated. Mr. F. J. Cook had put forward a formula which gave good results in practice, and within very small limits it was permissible to work on a basis of total carbon plus silicon as constant, which implied that an increase in one element could be offset by a diminution in the other, provided the total remained constant. The proper figure for this total varied with the method of cooling, but in the best modern irons was not much above 4 per cent. The pearlitic structure (combined carbon 0.7 per cent.-0.9 per cent.) was aimed at, and phosphorus should be 0.2 per cent.-0.4 per cent., with sulphur 0.1 per cent. and manganese about 0.8 per cent.-1.0 per cent.

The influence of rate of cooling on structure, and hence on mechanical properties, must be considered. The more quickly metal cooled the greater was the extent to which the carbon was retained in the carbide form, with the result that it was hard and brittle. Thus, if casting conditions necessitated quick cooling, as in chill moulds or centrifugal casting, high total carbon and high silicon were required to enable the graphitisation to take place. On the other hand, if the casting conditions demanded slow cooling, obviously these graphitising elements should be kept to a minimum. The desirable rate of cooling was that which resulted in the whole of the metal changing to the pearlite form without that further change from pearlite to graphite and ferrite. Three factors affected the rate of cooling. Clearly the hotter the metal when poured from the cupola, the longer a given mass would take to cool down: secondly, other things being equal, the thicker the casting the longer it would take to cool: and thirdly, the hotter the mould the longer the cooling rate, and *vice versa*. The factors influencing the rate of cooling were therefore pouring temperature, mould temperature, and casting thickness. Obviously, pouring in chill moulds would necessitate a higher silicon and total carbon if a machinable iron was required. Pouring in a dry-sand mould would give slower cooling than pouring in a green-sand mould, and if still slower cooling was necessary this could be accomplished by pouring in a heated mould. The damaging influence mechanically of the phosphide eutectic was nullified and, in point of fact, the mechanical properties of the metal itself might actually be increased, if the phosphide eutectic was distributed in the well-known network formation. This factor was dependent upon the rate of cooling, but further investigation was required before they could definitely be sure of always getting the network in any casting. Slow-cooled irons invariably had their graphite in large and flaky form, whereas chill cast irons had graphite fine and well distributed. The smaller the graphite flakes and the more even the distribution, the stronger the iron.

The improvement of ordinary grey iron might be effected (1) by reducing the amount of elements present in ordinary grey iron which formed compounds interrupting the main structure and which were in themselves of inferior mechanical properties; of these phosphorus and graphite were the chief. (2) By arranging a rate of cooling which would secure the maximum carbon in the combined form consistent with a uniformly machinable iron. This fixed the combined carbon at approximately 0.9 per cent. and the matrix of the iron as pearlite. Pearlite behaved as, and had to be treated as, a single homogeneous material. (3) By arranging the particular composition and rate of cooling to give particular mechanical properties.

Mr. Pearce described the production of Lanz hot mould iron, Schuz iron and Emmel iron, and exhibited a number of slides illustrating their structure. He added that decided improvements were taking place in the properties of grey iron. Such properties could be supplied by founders to the requirements of engineers, but to do so called for the highest skill in the founding art, as well as first class raw materials and foundry control. Such irons, therefore, cost more than common grey irons, but their use should enable reductions of sections to take place with diminished costs and freights of engineering products into which they entered. In certain cases they might replace cast steel and other materials which had displaced cast iron in recent years. While the cases used for purposes of illustration were German, developments were taking place in other industrial countries, notably France, the United States and Belgium. Nor were British manufacturers behind. It had been established over and over again that British founding was, so far as the quality and finish of its products were concerned, ahead of other countries, and the British Cast Iron Research Association was rapidly meeting the main deficiency of the industry—a lack of organised and systematic experimental work on a large scale with the object of enabling founders to improve quality and economise on production costs.

In proposing a vote of thanks to Mr. Pearce, Mr. D. Wilkinson said they had listened to an extremely interesting lecture and had seen some very creditable slides. Personally, he wished there had been a little information on the point of how to keep down total carbon in cupola melted iron.

Mr. F. C. Edwards, in seconding the motion, commended the non-technical language employed throughout the address. It was very important, he considered, that those who came to learn should be assisted to do so by having information presented to them in an easily digestible form.

Mr. Pearce, speaking in acknowledgment, said he had a great deal of sympathy with the remarks made by Mr. Edwards. Each of them had different jobs to do, and if they could not talk about them in language which was more or less generally understood they might just as well not talk at all. He did not know a more difficult job than to talk to a meeting of the I.B.F., for the reason that it embodied in its constitution so many different types of people. They were all interested in the same thing, but from different angles.

Cast Iron for Electrical Machines.

By J. H. Partridge, B.Sc. (Hons.) (University of Birmingham).

(*Continued from page* 41.)

Malleable Cast Iron.

Two specimens of black heart malleable cast iron, kindly supplied by Messrs. Leys Malleable Castings Company, Limited, of Derby, were tested.

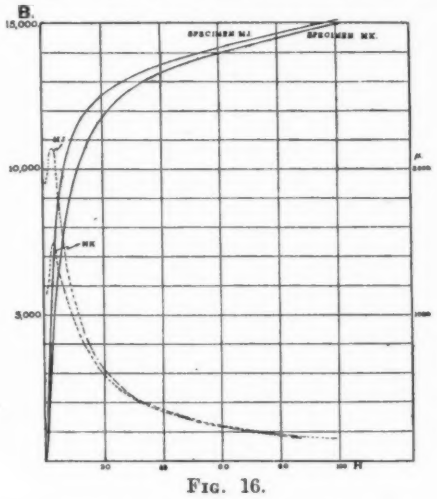


FIG. 16.

The analysis is given in the table below, whilst the primary magnetisation and permeability curves are shown in Fig. 16.

Specimen.	T.C.	G.C.	C.C.	Si.	Mn.	S.	P.
M.J.	1.90	1.69	0.21	0.89	0.29	0.036	0.123
M.K.	1.64	1.30	0.34	0.97	0.30	0.036	0.123

A summary of the magnetic properties obtained from these curves is given in Table XXIII.

TABLE XXIII.—*Magnetic Properties of Black Heart Malleable Iron.*

Specimen.	B max. (H = 100)	μ max.	H for μ max.
M.J.	15,150	2,140	3.0
M.K.	14,950	1,490	3.24

Hysteresis losses were determined, the results of the tests being given in Table XXIV.

TABLE XXIV.—*Hysteresis Losses of Malleable Iron.*

Specimen.	Limits of induction between which loss was determined.	Coercive force.	Hysteresis loss in ergs per c.c. per cycle.	Hysteresis loss in Watts per lb.	Density
M.J.	10,500	2.17	6,799	4.235	7.281
M.K.	10,000	2.36	7,010	4.380	7.259

Thus black heart malleable cast iron has a very high induction and permeability combined with low hysteresis-loss, and low coercive force. The difference in the permeability of the two specimens is probably due to the difference in combined carbon, specimen M.K. having 50 per cent. more combined carbon than specimen M.J.

The Relationship Between the Structure of Cast Iron and its Magnetic Properties.

The magnetic properties of cast iron depend to a very great extent upon its structure. Consideration of both structure and chemical composition is necessary if results are to be interpreted correctly, otherwise magnetism would appear to be a very capricious property. A few photo-micrographs are given to illustrate the principles underlying the relationship between structure and magnetism.

Figs. 17, 18 and 19 show the micro-structures of Specimens 5, 6 and 10. Specimen 10 is in the cast state, and has a pearlitic ground mass, while Specimens 5 and 6 have been annealed, and consist mainly of ferrite. The micro-structures of Specimens M3, M5, A5 and C6 are illustrated by

FIG. 17.—SPECIMEN 5, ETCHED × 100.

Figs. 20, 21, 22 and 23 respectively. All these specimens have a pearlitic ground mass, and free cementite is also noticed.

Thus for the highest magnetic-induction and permeability a ferrite ground mass is essential. The

FIG. 18.—SPECIMEN 6, ETCHED × 100.

amount of pearlite should be as low as possible. The presence of free cementite is a sure indication of low magnetic induction, and should be avoided at all costs when high permeability is required.

D

The presence of free carbide also indicates high coercive force, high hysteresis loss, and low remanent magnetism.

The structural change in Specimens A5 and A6 on annealing is illustrated by Figs. 24 and 25.

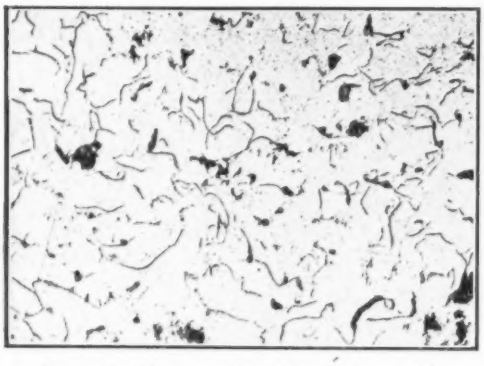


FIG. 19.—SPECIMEN 10, UNETCHED × 100.

(Compare Figs. 22 and 24). The carbide has decomposed, leaving the graphite as small nodules in a ground mass of alumino-ferrite. The permeability of these specimens was increased tenfold by this change, the induction was doubled, and the

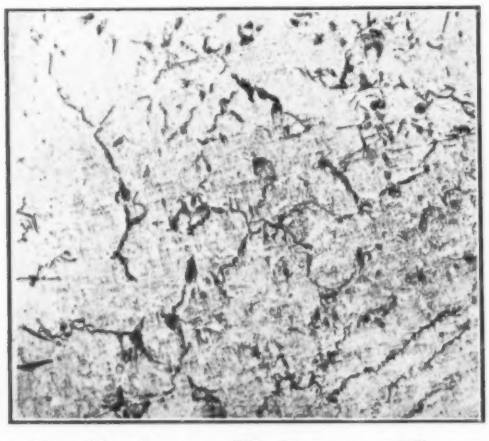


FIG. 20.—SPECIMEN M3, ETCHED × 100.

hysteresis loss was decreased to less than 10,000 ergs. The hysteresis loss of these specimens in the cast condition would probably have been well over 30,000 ergs. The high induction, high permeability and low hysteresis loss of these specimens

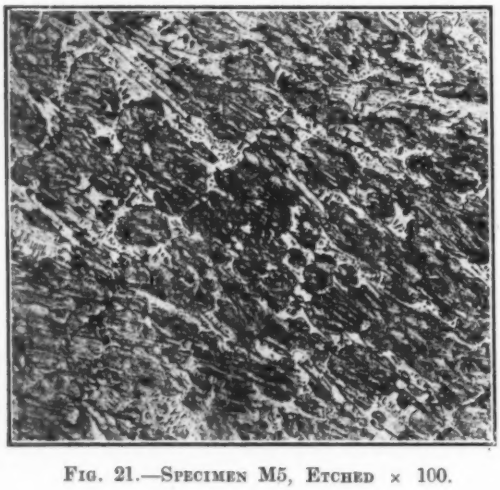


FIG. 21.—SPECIMEN M5, ETCHED × 100.

is due to the large amount of ferrite and the presence of all the carbon in the nodular form as temper carbon. The micro-structure of Specimen M.J. is shown in Fig. 26, from which it is seen that this specimen consists of ferrite grains and temper carbon. The structure readily explains the high induction, high permeability and the low hysteresis loss of this specimen.

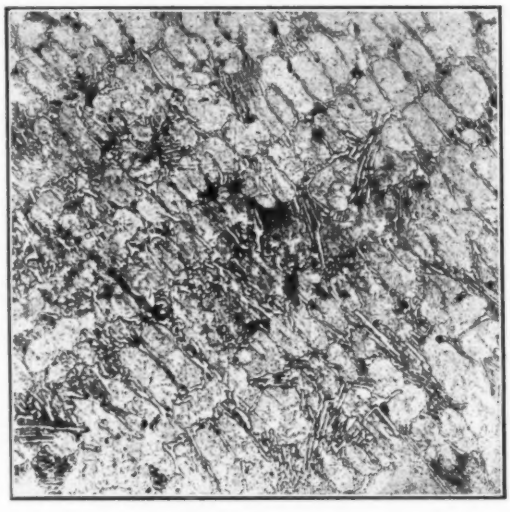


FIG. 22.—SPECIMEN A5, ETCHED × 100.

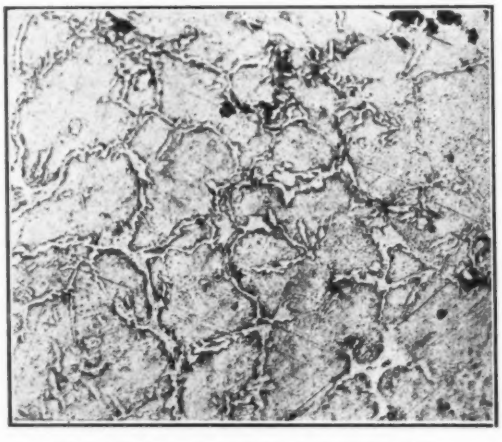


FIG. 23.—SPECIMEN C6, ETCHED × 100.

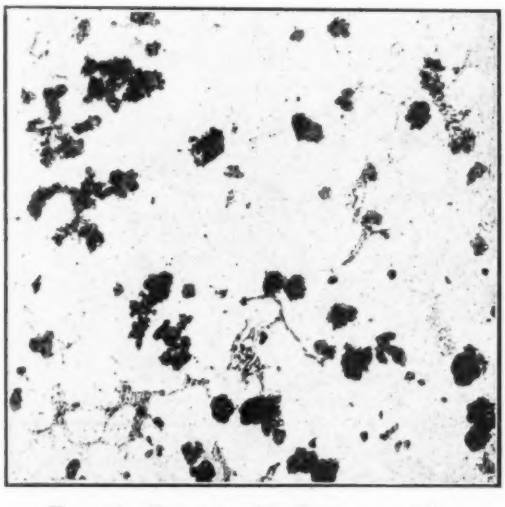


FIG. 24.—SPECIMEN A5, ETCHED × 100.

Summary and Conclusions.

1. The highest magnetic induction and permeability are obtained with cast iron which has

been annealed. In the extreme case the magnetic induction was increased 70 per cent. and the maximum permeability was increased tenfold on annealing.

2. When high permeability is required, the graphite should be in the form of temper carbon,

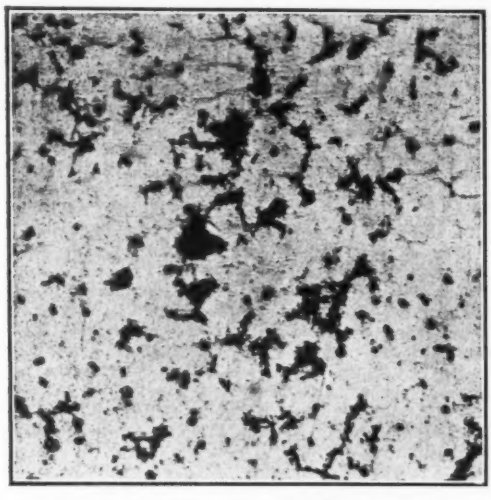


FIG. 25.—SPECIMEN A6, ETCHED × 100.

as little combined carbon as possible should be present, and free cementite must be absent.

3. In the cast state, silicon decreases the magnetic induction, but its presence may be advantageous in alloys which have to work at low flux densities (*e.g.*, transformer cores). Specimen 15

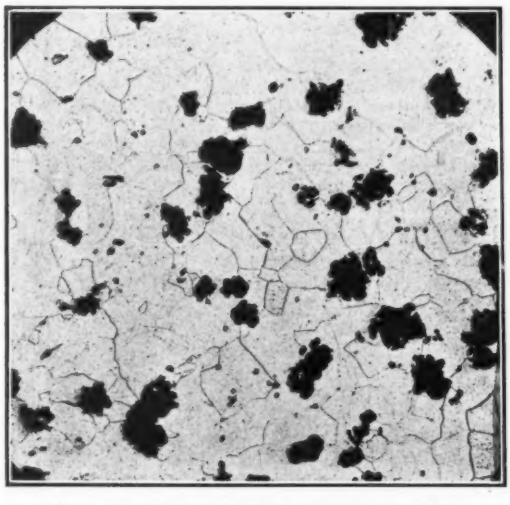


FIG. 26.—SPECIMEN M.J., ETCHED × 100.

is an example of an alloy which is very magnetic in comparatively weak fields, having a permeability of over 1,000 c.g.s. at a field strength of 2.0 gauss.

4. Both in the cast and annealed conditions silicon reduces the coercive force and the hysteresis loss. In the case of Specimens 10 and 15, the hysteresis losses are remarkably low, being equal to that of very soft iron. In the case of Specimen 15, the low hysteresis loss is remarkable, since it occurs in a cast alloy.

5. Both in the cast and annealed conditions manganese, nickel and chromium are prejudicial to high magnetic induction.

6. In the annealed condition manganese and chromium increase the coercive force and hysteresis loss and decrease the remanent magnetism.

7. In the cast state aluminium decreases the magnetic induction, permeability and remanent magnetism, and increases the coercive force and the hysteresis loss.

8. In the annealed condition aluminium, in amounts up to 1 per cent., decreases the magnetic induction and the maximum permeability, but increases the coercive force and hysteresis loss. When present in amounts from 1 to 3 per cent., however, aluminium causes a huge increase in the induction and permeability, Specimens A5 and A6 having inductions of over 13,000 c.g.s. and permeabilities of over 1,000 c.g.s. It also causes a heavy decrease in the coercive force and hysteresis loss. The coercive force and hysteresis loss of Specimens A5 and A6 are very little greater than those of soft iron.

9. The presence of sufficient nickel, or nickel and manganese, makes cast iron non-magnetic. Sufficient of these elements must be added to render the iron entirely austenitic, the presence of martensite making the iron feebly magnetic, hard and difficult to machine. An easily machinable non-magnetic cast iron could be made by having nickel and manganese present in such proportions that the combined effect of these two elements on the carbon is negligible. Sufficient silicon would then be added to precipitate just sufficient graphite to give the required strength, machining properties, surface, etc.

10. Malleable cast iron possesses high induction and permeability and low hysteresis loss and coercive force.

11. The presence of graphite does not prevent the attainment of low hysteresis losses, but when high permeability and induction are required, the amount of graphite should be as small as possible. Thus the high permeability (2,500 e.g.s.) of black heart malleable cast iron is due to the small percentage of graphite, and pearlite.

In an article in the "Electrician" of August 7, 1925, Mr. O'Neill deplored the lack of information on the magnetic properties of cast iron, and urged that this material ought to be studied from the standpoint of its magnetic properties. He stated that "most grey irons have a hysteresis loss of from 30,000-40,000 ergs per c.c. per cycle, although Hopkinson reports tests on a bar of this material (analysis not given) showing an energy loss of only 13,000 ergs. The coercive force of his sample was only 3.8, so that its behaviour was surprisingly similar to that of cast pure iron." This statement is typical of the general opinion, formed 25 years ago, of the magnetic properties of cast iron. The author has endeavoured to prove that the above statement by no means applies to all cast irons, and that it is possible to produce cast iron with a hysteresis loss equal to that of soft iron, certainly less than that of wrought iron or mild steel. This class of cast iron should enable cast-iron frames to be used in the electrical industry. Poles could then be cast with the frame, thus avoiding joints, which are very undesirable. Cast iron has the advantage of high electrical resistance. The resistance of Specimen 15 is about eighteen times the resistance of a similar bar of soft iron. This high resistance would reduce the eddy currents in the case of alternating current generator, thus resulting in considerable saving. Cast iron also has the advantage of cheapness, convenient casting properties and low melting point. A great disadvantage of cast iron in the cast state is the relatively low induction and permeability compared with black heart malleable iron. However, when cast iron is malleabilised in order to produce high induction and high permeability, the electrical resistance is greatly reduced, being only some three times the resistance of soft iron. However, the author doubts whether it would be economical to produce a malleable cast-iron frame for an electric alternator.

In conclusion, the author wishes to thank Professor Turner not only for indicating such an interesting subject, but also for his kind interest in the work and for his many valuable suggestions. He also desires to thank Professor S. W. J. Smith for giving every facility for carrying out the magnetic determinations, and for his kind interest in the work, which has been carried out in the Metallurgical and Physical Laboratories of the University of Birmingham, with the assistance of a grant from the Department of Scientific and Industrial Research. The author is indebted to the staffs of the Laboratories and to his fellow research workers for help and encouragement. His thanks are also due to the British Cast Iron Research Association, and particularly to Mr. S. E. Dawson, Member of Council of that Association.

Production of High-Strength Cast Iron.*

By Chief-Engineer Gilles (Berlin).

[*Slightly Abridged.*]

The question of improving the mechanical properties of grey cast iron has of late years occupied the minds of progressive foundrymen, yet so far it has not admitted of a general solution. True, our scientific workers have furnished valuable hints, and we have heard of new processes due to practical men which have given good results, but it is premature to speak of producing very special cast iron on a broad basis—a sign that there are still many obstacles to overcome. Apart from the fact that in various quarters proposals have already been made to classify cast irons of maximum strength, the knowledge that it is possible to produce machinable grey cast iron of tensile strength exceeding 25 tons and a transverse strength of some 38 tons is sufficient inducement for us to go into the matter more thoroughly.

Reference is specifically made to "strength," and not of the general value of castings, which, after all, depends on the methods used in practice and which it is not proposed to touch upon here. In considering the efforts that have been made, however, the author would protest against the term so much used of late, viz., *refining* of cast iron. The most refined and valuable material, if cast in an unsuitable mould, will give a product that cannot be used.

Present Position.

For this purpose the data that appeared last year in Rudeloff's exhaustive reports on experiments made to determine the degree of certainty attainable in the foundry is recalled. This work, commissioned by the German Ironfounders' Association, and carried out under the supervision of a number of foundry specialists of acknowledged standing, gives a true account of how things then stood. One of the tasks set was to compare the strength of the product turned out by the different foundries involved, all using the same prescribed material and working on the same lines. Despite the use of the same mixture, the results varied widely, transverse figures ranging from 21.5 to 27.5 tons, while the tensile strength gave values from 10.75 to about 15 tons per sq. in.

A further point was to determine with what degree of certainty the various foundries, with their own mixtures and employing usual practice, could turn out iron conforming to certain requirements. These included a mean transverse strength of 17.8 tons with a deflection of 0.28 in. and an upper limit of transverse strength of 21.6 tons with a deflection of 0.39 in. Here, again, there were wide fluctuations, the range being from 21.5 to 31.3 and from 11.5 to 16 tons.

There was nothing very new in these results, *per se*, but the investigations were of value to this extent that, carried out as they were systematically and on a uniform plan, they confirmed the actual experience of each individual founder. What is here spoken of as *high strength* corresponds more or less with the specifications laid down by the State Railways which up till a few years ago called for a tensile strength, in cylinder iron, of 11.4 to 15.25 tons. Fixing the upper limit at 15.25 tons (it was later raised to 16.5) certainly gave the foundrymen no incentive to look for a material of much greater strength. How often has it happened that the railway officials have objected to cylinders owing to their being too strong. The demand, that the mixture be changed, was often met by making the test-bar stronger. Certainly, in fixing said upper limit, the idea was to exclude castings that might be too hard, but this was an unnecessary apprehension, for the machine shops would have rejected such material in any case.

Melting Facilities.

The fact that a foundryman occasionally, but without deliberate intention, produced iron of unusual strength, led him to suspect that there were unknown values still hidden in grey cast iron, but the long war and post-war period gave him no chance to go into the matter more thoroughly. Again, the cupola's bad reputation for reliability caused many a foundryman to wait till someone should produce a more perfect melting device. More than 20 years ago there was available an oil-fired cupola, designed to turn out a better product, and while for long one hoped for its advent, it was only in isolated cases that it was ever installed. No outstanding successes were registered; in fact one heard less and less until, a few years ago, there came into being the Wuest oil-fired cupola. Even the ordinary reverberatory furnace, coal- or gas-fired, which certainly produces a good iron, has only been adopted for heavy castings such as rolls and the like. This is due to the cost of installation, the greater fuel-consumption as against the cupola, and the necessity for emptying the whole charge as soon as ready, whereas in most foundries it is desirable to be able to tap continuously.

The foundryman always had an ideal at the back of his head, viz., the electric furnace, and it must be admitted that it offers the greatest possibility of attaining any desired composition, and of holding temperatures within suitable limits.

Electric Furnace Iron.

A few weeks ago German foundrymen had an opportunity of listening to an exhaustive report by Kerpely on the production of grey cast iron in the electric furnace, and, on the whole, they found their expectations as to high strength realised. Doubts have been cast in other quarters on the accuracy of Kerpely's analyses, but it is desirable not to enter upon this dispute here, although personal experience led the author to think that the carbon-contents, for example, appeared on the high side. While foundrymen will have to await further developments in electric furnace practice leading to greater perfection, it is thought no one, be he theorist or practical man, will have anything to say against the electric furnace except it be on the score of costs. Like other branches of industry, the foundry suffers from want of capital, and one can hardly look for any great improvement in this respect for the next few years. The cost of current, moreover, will not fall to such an extent as to make it an economical proposition to manufacture cast iron in the electric furnace, even if resort was made to the so-called Duplex process, *i.e.*, refining cupola iron in the electric furnace. Even here the advantage of continuous tapping would be lost.

There have been good reasons for the constant attempts made to improve the cupola, which cannot be improved upon for fuel-consumption. Many new processes and constructional modifications such as the addition of refining media in briquette form, desulphurisation in conjunction with the "Rein" slag-separator, the Schuermann furnace, etc., have certainly done their bit in exercising a favourable influence on the quality of the cupola material and the cost of production.

Perlit Iron.

A particularly satisfactory achievement has been signalled by Diefentaeler and Sipp in that they have placed on a systematic basis an already known process for improving the mechanical properties of cast iron. In "Stahl und Eisen" (No. 17, 1923), Professor Bauer treated of this process, which consists essentially in mixing the cupola iron with due regard to the thickness of sections in the castings and pouring into preheated moulds in order to regulate the cooling, and he reported the results of very satisfactory experiments. Both transverse and tensile strengths, resistance to shock, impact and sliding friction were better than in cylinder iron, so that the development of the process appears to mark a decided step forward in the direction of improving the material. Whereas at that time metallography was but little, if at all, employed in

* Translated from "Giesserei Zeitung," April 15, 1926.

the iron foundry, it must be laid to the credit of Diefentaeler and Sipp that, as practical men, they examined the structure of their product under the microscope, and found confirmation of what scientfic workers had deduced as to the formation of such structure. In 1916 Diefentaeler got his process patented, and a violent dispute has arisen as to the interpretation of his claims. Were it merely a question of a dispute about patents between a number of concerns, it would not be in order to enter upon the matter here, but since the dispute in question is one that must interest every ironfounder, one must go a little closer into it when discussing efforts in the direction indicated. It is for this reason that the author turns to the historical side.

Hot Moulds Used in 1847.

In Duerre's "Complete Ironfounder's Handbook" (the 1875 edition) there appeared on p. 819, where the author speaks of a process for producing good, strong cast iron, the following:—

> "Still more striking is the effect of slow cooling on the strength of cast iron. An experiment was made in Boston in 1847, when two six-pounders, *i.e.*, cannon, were tapped from the same furnace. One was cooled in the ordinary way, but the other was cast in a red-hot mould heated by a fire in the pit. At the end of the fourth day the mould was taken out, and on the fifth day it was opened."

Duerre goes on to describe the *Rodman* casting process, which used water-cooling in the core-spindle, while at the same time the mould was externally heated after the metal had been poured in. "This," he says, "produces a molecular change which does not occur in the same way in any other cast iron."

Fig. 1 is taken from this Handbook, and it will be seen that the casting-box stands in a pit which is fired. The core-spindle is hollow, but is not seen thus on the present drawing, which is on a very small scale. Through it flows cooling-water to produce a fine, hard structure in the interior of the casting, whereas the external mould is held at a red heat to make the exterior solid and tough.

The Sequel.

It has for long been known that slow cooling of a casting induces strength. Scientists speak, in the first instance, of a molecular transformation. Using the microscope, research workers, in such grey iron as has been gradually cooled, find, as Ledebur says in his book on "Pig-Iron," the ground-mass dissociated into two intimately intermingled and yet clearly identifiable bodies, viz., pure iron or so-called ferrite, and the carbide Fe_3C, known as cementite. In this case the ground-mass is called pearlite, as having a sheen like mother-of-pearl.

This name, *Pearlite*, which was coined by Sorby, is claimed by the holder of the above-mentioned patents for himself alone, not merely as a name, although he calls his product Pearlitic cast iron (perlitische gusseisen), but he even wishes to establish the principle that no pearlitic structure shall be caused to appear in any cast iron without his permission, even where due to some process other than his own.

The German Law Case.

Most people will have read that the Heinrich Lanz concern, of Mannheim, as holders of the patent referred to, are suing the Esslingen Works and Thyssen & Company, and seeking an injunction whereby the latter, under a penalty of up to six months' imprisonment, shall be restrained from maintaining that pearlitic cast iron *can be made without patent-holder's permission*. The defendants' claim is no more than that of all foundrymen who make special cast iron, as they have been doing for generations past.

The question as to whether grey iron castings show pearlitic structure or not might conceivably be a matter of sublime indifference to customers. Assume that, for special purposes, a cast iron of optimum mechanical properties is called for. Such iron will show pearlitic structure, whether the foundryman sets out deliberately to produce it or not. Imagine, then, the confusion that will ensue should the plaintiff win the case. We might then be compelled to make the following statement on oath:—"We promise not to make any more pearlitic cast iron," although, to salve our consciences, we should have to say:—"Yet, it will still be pearlitic cast iron." We are strongly reminded of a case, admittedly of greater importance, that happened in the Middle Ages. Further, it would automatically remove all the worry we now go to in the effort to produce better cast iron, for even if we tackled it in a way quite different from that employed by Lanz, they could still forbid us to do it.

Emmel's Results.

It was stated that foundrymen should let the matter lie till the Courts had pronounced judgment. That is all very good, but what and how are the legal authorities to decide in a matter that offers thorny difficulties to laymen, when the experts themselves have not gone into the matter properly and satisfied themselves as to the effects the decision might produce. Personally, the author thinks the German ironfounders have every reason to thank Messrs. Emmel and Greiner, who have protested against the sweeping construction put on the patent claims, for upholding their interests. It was the more fitting that the initiative should come from them, as both have successfully busied themselves with the question of improving grey cast iron. Every founder's heart must have bounded on reading Emmel's article entitled "Low-Carbon Cast Iron as a Cupola Product" in "Stahl und Eisen" for August, 1925. Tensile figures up to 25.5 and transverse values up to 44.5 tons and even beyond are results hitherto unknown in cupola practice. It is to be regretted that up to the present Emmel has made no further disclosures as to his process, and one must be content to acknowledge these brilliant results, with the hope that in the very near future a greater number of foundrymen will have an opportunity of testing the method and attaining the same results.

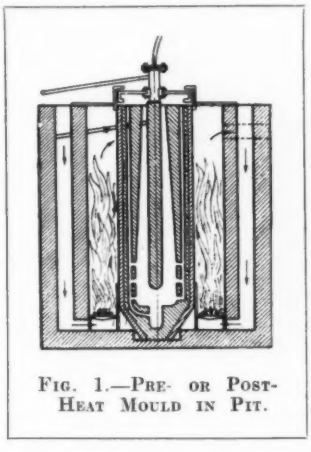


FIG. 1.—PRE- OR POST-HEAT MOULD IN PIT.

Wuest Cupola and High Tensiles.

In the same issue of "Stahl und Eisen" there was a report by Dr. Klingenstein on "Practical Experiences with an Oil-fired Wuest Cupola," in which he also spoke of tensile values of 21.2 tons and transverse strengths of 34.7. It is but natural that one should welcome this furnace as a desirable substitute for the expensive electric furnace. The hearth has a capacity of one ton, and the charge is ready for tapping in one hour. The oil-consumption is about 11 per cent., a further 20 kilos, or 2 per cent. being used for heating up. The temperature of the molten iron in the trough is from 1,500 to 1,600 deg. C. As with the ordinary cupola, the charge is put in from the platform with 1½ per cent. of limestone, but of course without coke. The analysis of the product giving the figures quoted ran as follows: C, 2.7; Si, 1.66; Mn, 0.90; P, 0.42; and S, 0.077 per cent. A furnace of this type has also been in operation at the author's works for some nine months now, and after a number of troubles such as are always experienced with new designs, the works have brought things to a point

where the mean temperature of the iron is 1,550 deg. C. and the oil-consumption about 13.5 per cent.

The attainment of such high temperatures as these is one of the essential points in the production of cast iron of high strength. In general, it has ever been the endeavour of the foundryman, where he had a special iron to produce, to aim at hot melting down of the charge in the cupola, but in ordinary working he rarely gets much above 1,400 deg. C. The pearlitic structure alone will not give high strength, for much depends upon the stratification of the graphite. In a thin section the difference in graphite-structure and the effects due to its presence in elongated sheets or fine distribution are easily recognised.

Value of Superheating.

The recognition of superheating as a factor producing fine distribution of graphite is of much more recent date. Only last year, at the general meeting of Verein Deutscher Gessereifachleute in Munich, the experts expressed widely divergent views in the discussion following Professor Diepschlag's Paper on the "Refining of Cast Iron." Although a number of points still remain obscure, various independent experiments in actual practice go to support the theory of Piwowarski, whose labours in this field have frequently furnished valuable hints. It was satisfactory to glean from a lecture by Professor Hannemann on the "Theory of Cast Iron" that his researches had led him to similar conclusions.

Dr. Schuetz has also confirmed the formation of a graphite eutectic in conjunction with extra strength in high-silicon cast iron that has been rapidly cooled. The foundryman chose a mixture with 3 per cent. of silicon, or even more, which he cast in a chill and produced a springy ring of very fine grain. But, just as is the case with pearlitic iron, he did not attempt to give a metallographical explanation for his success, *i.e.*, he was quite unaware that by this simple process he had produced a graphite eutectic. This is a further proof that it would be wrong to protect by a patent the scientific recognition or explanation of a process that had been carried out in an empirical manner.

The amalgamation of the general language of the physicist with the special argot of the metallographer has caused confusion in the construction or interpretation of the Lanz patent claim. The claim* runs as follows: "Process for producing grey cast iron of special resistivity to sliding stresses, the essential feature being that by suitable mixing and by cooling down in a manner having relation to such mixture, provision is made whereby the structure of the finished casting is characterised by its consisting chiefly of lamellar pearlite." Translated into ordinary language this reads: "Process for the production of extra strong cast iron, characterised by the fact that, due to suitable mixing and corresponding cooling, an extra strong cast iron is obtained." Now, what is it sought to protect—a method or a product?

The chemical composition necessary for strength in cast iron has been known for a long time. Ledebur's data are still valid. The work of Wuest, Goerens and others on the mutually reciprocal effects of the various elements, and on the thickness of sections and cooling conditions respectively, still retain its fundamental importance. For a long time now foundrymen have been aware that, for example, an iron for sections of 1 in. with, say, C 2.7 to 2.8, Si 2, and Mn 0.6 to 0.8 per cent. and the least possible phosphorus and sulphur would yield a final product of great strength, but foundrymen are not so familiar with the idea that a high melting temperature would make it still better.

Cupola Remains Essential Feature.

Still, how is one to set about making such an iron without the expensive electric furnace? The advantages of the cupola are well known. For fuel consumption it has no superior, and it provides liquid iron either in small quantities or large, especially if there is a forehearth attached. It is easy to repair and always ready for action.

* This translation refers to the German and not the British specification.—EDITOR.

The question, therefore, resolves itself into the task of producing an iron of the above-mentioned composition in the cupola, assuming that there is available good pig-iron and scrap. There should be no difficulty with silicon, manganese, phosphorus and sulphur, and if the last-named should give any trouble there is nowadays media wherewith to minimise its effect. But the low carbon-content and the superheating have hitherto been unattainable in the cupola. Again citing Ledebur, who, even when he was melting 90 per cent. of steel scrap, found the cast iron to have over 3 per cent. of carbon, and Klingenstein, in the article previously quoted, said that even using wrought iron only gave a partial success, as generally one could only come down to 3.1 to 3.2 per cent. carbon, unless one was dealing with very thick sections where superheating was not called for.

Producing Low Carbon.

As a matter of fact, one has hitherto been accustomed, in good strong cast iron, to reach a carbon-content of some 3.2 per cent., using steel crop ends or special low-carbon iron such as Concordiahuette. This Concordia iron, which, as is well known, has been brought down to a carbon-content of 2.6 to 2.8 per cent. by using Henning's suggestion of adding liquid steel to pig-iron, showed greater strength when cast in corresponding sections than did the actual cupola product using the self-same material, as the author himself proved years ago at the Concordia plant.

The use of large quantities of steel crop ends, etc., in the cupola was extensively exploited during the war, and not only in Germany, on account of the shortage of pig-iron. It is presumed that nobody now looks back longingly on that product (which was incorrectly styled "semi-steel"), for there was wanting a suitable process to produce economically the required silicon and manganese contents, while the sulphur-content, through using runners and risers over and over again, passed all reasonable limits. The addition of ferro-silicon and ferro-manganese in the ladle or even in the charge caused such loss of these valuable alloys as made the proposition uneconomical, despite the cheap material in the charge. The silicon and manganese briquettes introduced by the Esslinger Works mark a decided step forward in this connection, and have encouraged the continuance of experiments with a large proportion of steel scrap. In this way there is an assured solution of the problem. Corsalli, who also worked for years on the briquetting of ferrous alloys, covers his silicon and manganese packets with a crust or an iron shell to prevent losses, and this is the more important as, where the charge is low in carbon, he insists on melting with an excess of blast. His idea is thus to refine direct. He permanently interrupts the absorption of carbon from the coke, and actually gets a cast iron with a carbon-content of 2.5 to 3.0 per cent., all according to the increase in the volume of his blast. It is easy to see that the furnace will run hotter, due to the greater amount of oxygen introduced. To drive the furnace still more and prevent decomposition of the carbon dioxide, Corsalli suggests using charge-coke of low reactivity, as did also Piwowarski in his lecture last year before the German Ironfounders' Association in Düsseldorf. It is to be hoped that in the near future some plant will be prepared to take up a process for producing coke of this sort.

Treating Coke for Retarding Combustion.

In personal experiments the author has made shift by using, for charge-coke, material that had been dipped in limewater, with the result that the coke reached the melting zone unburnt. In this manner a temperature of beyond 1,500 deg. C. in the spout of a 5-ton Krigar furnace that had no forehearth was obtained.

Further to prevent losses of silicon and manganese at such a working heat, the refining media should be introduced direct from the outside into the cupola at the level of the melting zone, and should flow in liquid form from a melting device heated by the cupola waste gases.

It is obvious that, when using the process as a whole, it is of advantage to have a furnace with a forehearth, the latter being heated and of shallow design as opposed to the usual rounded

form. There is no difficulty in superheating iron from 1,500 up to 1,550 or 1,600 deg. C. with oil-burners. As the temperature has only to be raised a matter of 50 or at most 100 deg. C., it would be advisable to find out whether electrical heating of the forehearth is at all feasible and economic. In such a combination as proposed we should find all the advantages both of the cupola and of the electric furnace.

Data relating to the heats made with the cupola after the manner described will be found in the following Table I.

TABLE I.—*Composition and Strength of Various Special Irons.*

	T.C.	Gr.	C.C.	Si.	Mn.	P.	S.	30 mm. test bar. unmachined.		20 mm. test bar machined
								Transverse.	Deflection.	Tensile.
Ordinary grey cast iron	3.37	2.97	0.40	2.36	0.49	0.71	0.084	19	7.3	7.7
Lanz Pearlitic ,, ,,	3.08	2.01	1.07	1.12	0.80	0.28	0.195	32.2	8.1	20.4
Oil furnace ,, ,,	2.74	1.84	0.90	2.25	0.99	0.33	0.074	29.4	6.5	18.8
Cupola ,, ,,	2.98	2.06	0.92	1.62	0.86	0.29	0.138	37.5	8.0	21.7
,, ,, ,,	2.95	2.00	0.95	1.57	0.78	0.28	0.132	35.6	6.3	22.9
,, ,, ,,	2.90	1.98	0.92	1.53	0.83	0.29	0.134	34.9	6.3	24.1
,, ,, ,,	2.94	1.98	0.96	2.09	1.07	0.22	0.111	34.0	6.6	22.1
,, ,, ,,	2.77	1.94	0.83	2.00	0.89	0.25	0.137	35.6	6.6	24.6
,, ,, ,,	3.00	1.86	1.14	2.03	1.19	0.27	0.146	39.7	6.3	25.1
,, ,, ,,	2.88	1.96	0.92	2.29	0.75	0.21	0.185	35.8	7.5	22.6
,, ,, ,,	2.77	1.95	0.82	2.06	0.74	0.25	0.165	33.3	6.1	23.6
,, ,, ,,	2.90	2.01	0.89	2.09	0.99	0.26	0.107	33.3	6.2	22.1

Practical Details.

The charge consisted of 60 to 70 per cent. steel or wrought-iron scrap and 30 per cent. of pig-iron, for which, in continuous operation, runners and risers were substituted. This is a much cheaper mixture than one made up of pig-iron, scrap and special irons, but it may be objected that if this method were followed on a large scale the price of steel scrap, which to-day is about 55s. per ton, would gradually rise or else a dearth of suitable material would set in. On the other hand, the oft-mooted question of the direct production of pig-iron increases in importance when the foundryman lays special weight on obtaining deliveries of low-carbon pig-iron.

The first entry in the table gives data relative to ordinary grey cast iron. The high graphite-content and the manner of its distribution do not make for great strength. The iron is traversed in all directions by elongated plates of graphite, mostly joined up one to the other. The corresponding etched micro section shows the typical ferrite formation round the veins of graphite.

Sample No. 2 is of Lanz pearlitic cast iron. In contrast to No. 1, the graphite-content is only 2.01 per cent., and the thin section shows much more favourable distribution under microscopic examination.

Sample No. 3 was melted in the Wuest furnace. The iron had a temperature of 1,550 deg. C. Produced in very different fashion to the Lanz product, it differs therefrom in component percentages—in some instances markedly so. Illustrations were shown exhibiting a good graphite distribution, and the lamellar pearlitic structure can hardly be distinguished from that of the Lanz product.

The other samples, Nos. 4 to 12, were made in the cupola by the Corsalli process. The total carbon-content is in almost every case under 3 per cent. and the graphite under 2 per cent. A series of microphotographs showed ideal graphite distribution and perfect pearlitic structure, although no attempt was deliberately made to produce it. In the analysis there is further to note that a high sulphur-content need give no trouble if given an opportunity to occur as manganese sulphide and not as ferrous sulphide. The figures relating to the strength of the Corsalli cast iron reach a height exceeding anything Lanz has so far published. The Brinell numbers range from 230 to 250. These experiments prove that a cast iron of maximum strength can be produced in the cupola without after-treatment.

Conclusion.

In the foregoing the author has attempted to sketch the various phases in the development of the production of better cast iron. Considerable success has, from the practical standpoint, already been signalled, and it is seen that various processes, quite independently of each other, attain the desired end, which cannot but be welcomed in the interests of the problem at issue. It would be unjust to refuse protection to an inventor, but it is equally unfair to expect the foundrymen in general to acknowledge claims, on behalf of one individual, embracing not only the desired goal but every possible way of reaching it, especially as he is not even put to the trouble of stating what these ways are. In view of the general economic situation, German foundrymen must put their best foot forward to improve the quality of their product and yet keep the cost of production as low as possible. In this they will succeed more fully and speedily the more experts or firms they get to co-operate. This once done they will soon regain even a good part of the ground they have lost.

DISCUSSION.

CHIEF ENGINEER ZERZOG (Munich) said the lecturer had shown the steps taken and the aims pursued by Lanz with a view to obtaining for himself the maximum amount of protection for pearlitic cast iron. This material, after all, comes from the cupola, as the lecturer showed. It is made in the electric furnace by the Brown-Boverie concern, while in Belgium it is produced in the small converter. Indeed, the speaker himself had succeeded in making it by this process. If examined the foundrymen would find the lecturer's remarks confirmed. At their general meeting in Munich Professor Diepschlag spoke on the "Improvement of Cast Iron," and referred more directly to the question of temperatures. In the discussion that followed the speaker pointed out that foundrymen must melt as hot as possible, and several other speakers agreed. It was now some time ago since he made experiments in connection with superheating in the cupola. It could be done, but it was not then an economical proposition. If now one turned to a comparison of the electric furnace with the cupola, one must make a distinction, inasmuch as one could use time and temperature to the same extent as one could do in refining. Up to 90 per cent. the cupola would maintain its place, and the remaining 10 per cent. would be left for refining, *i.e.*, making good material out of bad, a thing that cannot be done in Wuest's furnace, where the brickwork is not particularly durable. Again, to raise the temperature in an electrically-heated forehearth was not such a simple matter as might be supposed. He had made certain alterations in his laboratory to enable him to experiment in this direction, and he hoped to give his results at a later date. As far as superheating in the cupola was concerned, the Lindner Iron & Steel Works had given data relative to a process wherein silicon and steel turnings are briquetted together to form a protective medium against burning. He had had samples of these but, like Lanz, could not examine them by X-rays. He added that nowadays no one feared phosphorus and sulphur as they did a year or eighteen months ago. The sulphur-contents were still considerable, but when

in combination with manganese they did no harm. With phosphorus one could go to 0.3 per cent. Processes such as were carried out in the Schuermann furnace and other like apparatus had not now the value they had two or three years ago.

Attitude of Railway Companies.

Director Fuechsel (Berlin), referring to a remark made by the lecturer, said he would like to defend the State Railways from the charge that they had given no incentive to progress in the direction of better irons. Formerly there was some truth in it. They had only raised the upper tensile limit from 15.25 to 16.5 tons, but he did not believe that any cylinder was ever rejected for exceeding these figures. At one time it was feared that too high tensile strength would render machinability a doubtful quantity. That this need not necessarily be true had only been realised in more recent years. He insisted that the railways never looked askance at high-grade cast irons whenever offered by makers. As a matter of fact, Southern Germany has done pioneer work in this direction. On several occasions at general meetings, railway representatives have made it known that they were interested in so-called "Pearlitic" cast iron, and that for certain purposes they judged material by the appearance of its structure. The first experiments were made with Lanz's material, for the simple reason that he (Lanz) was the first to make it systematically and to arrive at the desired structure of deliberate intent. He did not propose to touch on the patent dispute, but would say that the Patent Office appeared to him to have gone to work in an unfortunate fashion by granting a patent covering both a process and the state of its final product. As the latter can be attained in three or four different ways, other makers cannot stand by and see such protection granted. In any case the other inventors who have hit upon pearlitic cast iron have likewise taken out patents, as witness the Emmel process and the Wuest furnace. The State Railways had always favoured the introduction of special cast iron for certain purposes, one instance being when the Committee on Standards was considering the establishment of a new class for grey cast iron with a tensile strength of 17.75 tons as a minimum. All the cupola products cited in the lecturer's table had a tensile strength of 19 tons. One advantage of these lies in their durability at the temperature of superheated steam. Pearlitic cast iron, as made by the Erbreich, Emmel and Lanz processes, holds its strength up to about 500 deg. C., and only commenced to weaken beyond this point. Not only the high strength but the durability at high temperatures are points in its favour. The graphite flakes show no coherent structure, but lie freely distributed throughout the pearlitic matrix. The oxygen in the hot gases has but little chance of getting at the graphite inclusions and so destroying the structure by oxidation. These points, in conjunction with the effect of the silicon-content, were already brought out by Campbell in a Paper at the last International Congress of the American Society for Testing Materials.

Lamellar Inferior to Emulsified Pearlite.

Dr. Linke (Eberswalde) brought up a point which, in the dispute about pearlitic cast iron, had not yet received the attention it merits. The Lanz material represents a cast iron whose carbon- and silicon-content is limited to 4.25 to 4.60 per cent. Emmel's product is a pearlitic cast iron of carbon-content much lower than 3 per cent., so that the total for carbon plus silicon is too low at 4.25 to 4.60 per cent., and one has to go much higher in this case. In Table I of the Paper it shows figures of 5 to 5.9 per cent. This by itself is sufficient to upset Lanz's claims as they are now formulated. In addition, he stipulates that the moulds have to be specially preheated. With the Emmel process this can seldom be done, and if it is at all possible, it is a question of simple moulds which come warm enough from the drying chamber. Otherwise it induces delays, which naturally raise the costs.

Another point was that in his own practice he had found that lamellar pearlite *is not the ideal* sought, but rather is an emulsified desired pearlite. Comparing the micrographs exhibited of Lanz pearlitic cast iron and that produced in the cupola, it is seen that the pearlite in the latter is in a state of still further dissolution. This is the cause of the higher figures for deflection and is a sign that the material has a greater capacity for work, which, after all, is the main thing. In his own works, devoted to crane manufacture, he made numbers of rope-drums and drumheads which are subject to shocks. Here it was essential that the iron have a great resistance to wear if it is to be used for rope-sheaves or pulleys. Resistance to wear and capacity for work are necessary. The latter is ensured by emulsified pearlite, which itself depends on high casting temperature and silicon-content. The carbon must hence be fairly low and this ensured resistance to wear. The works had reached as low as 2.5 to 2.7 per cent. carbon in the cupola. The first-mentioned figure cannot always be obtained, but they could practically depend on getting 2.6 to 2.7 per cent.

If one made iron by Lanz' method for a casting of 1 ft. cube with a thin rib which was still grey iron when the section was about 0.4 in., and then cut up this ingot, it will be found to be porous. With a cast iron, on the other hand, having less than 2.7 per cent. carbon, your product will be perfect, and this is essential for cut gears, which are subject to great stresses.

Ratio Between Tensile and Transverse Strength.

The tensile figures quoted, compared with those for transverse strength, appeared to him to be very high, as his general experience was that tensile strength was 46-50 per cent. of the transverse values, but here they range from about 55 to 65 per cent. That was something he failed utterly to understand. In this connection he mentioned that great care must be used with tensile testing machines for cast iron. One can test one and the same bar and get values of 16.5 or 20.3 tons. In the first case the bar will have bent a little; in the second, it will have been torn clean apart. It was no easy matter to find a suitable shape for the testbar that will not be open to some objection, for even where it passed from a conical to a cylindrical form there was danger of undercutting at the junction.

Importance of Casting Temperature.

Director Bannenberg (Dessau) raised the question of the effect of the temperature of the molten iron, and said that in the Giesserei Zeitung, No. 6 (1926) tensile figures of 23.9 tons are quoted where the composition was C 3.22: Si 1.76: Mn 0.93: P 0.45 per cent. Such foundries as have made cylinder iron for the railways to a specified tensile strength of 16.5 tons have generally arranged their mixtures to get an iron of about this composition. But, despite his high carbon-content, Kerpely obtained tensile figures that were higher by 50 to 60 per cent. True, his iron differed from the others inasmuch as it was made in the electric furnace. The only reason he could find for such high strength was the high temperature in the electric furnace and the time during which it acts upon the material. This went to bear out the ideas that were expressed in Munich at that time.

As far as the total, carbon plus silicon, is concerned, it emerges clearly from Dr. Maurer's well-known diagram, according to which the sum may even exceed the whole-number 5, especially when the rate of cooling is not reduced, otherwise one naturally had an orientation in the position of boundary-lines in the diagrams. Finally, as to the remark that the phosphorus-content plays no great role in the electric furnace exhaustive repeated-impact tests are required to throw light upon this.

Lanz Claims Criticised.

Dr. Klingenstein (Stuttgart) said the Lanz patent protected an alloy, viz., cast iron in which the sum carbon plus silicon totals 4.2 to 4.6 per cent., cast in a perheated mould. He would be satisfied if this were the construction put upon it. The ground for objection was that Lanz, as owner of the Diefentaeler patent, sought protection against any cast iron whatsoever containing pearlite, even without preheating; in other words, he claimed that any cast iron, wherein a pear-

litic structure is systematically produced, fell within his specification. Those concerned know that the patent, *per se*, cannot be upset, but the point was to get a clear interpretation of what was actually covered by it.

Someone mentioned that he was not clear why the formula stating that the tensile strength is half the transverse strength should not apply when one reached the higher tensile values. The reply was that tensile strength depended more on the graphite distribution than did the transverse strength. With increasing refinement of graphite the tensile strength increased in greater ratio than the transverse strength, as he showed in his article in the *Giesserei Zeitung* No. 9 (1926). Dr. Linke mentioned also that lamellar pearlite could not be looked upon as the ideal. He would go further and say that even pearlitic cast iron itself is not the last word in grey cast iron, and that he believed the goal to strive for was the production of eutectic graphite. In such material there would be but little pearlite. His firm had been working on these lines for years, and had lodged an application at the Patent Office covering a systematic method of producing this, so that he did not care at that juncture to go into fuller details.

Macroscopic Structure of Paramount Importance.

CHIEF-ENGINEER ZERZOG (Munich) said that pearlitic cast iron was made in many ways, deliberately or not. Soon, however, one would no longer speak of this material, but of others, as Dr. Klingenstein has just indicated. No reference had been made to the macroscopic structure. Kerpely mentioned the composition of cylinder iron, but gave no data as to the macroscopic structure. Some Swedish engineers recently said they attached more importance to the macroscopic as opposed to the microscopic appearance.

PROFESSOR DIEPSCHLAG (Breslau) pointed out that by suitable cupola working one could attain higher melting temperatures. According to Mr. Gilles, the temperature has been successfully raised to 1,600 deg. C. In a paper which he (the speaker) had read two years ago he calculated the theoretical combustion temperatures in the cupola, which range from 1,900 to 2,000 deg. C. Temperatures were generally much below these figures, but the gap would have to be smaller if greater efficiency and higher iron-temperatures are the ends sought. There was no doubt that by further systematic investigations and observations of cupola practice we should be able to raise the temperatures more and more.

CHIEF-ENGINEER KUESTER (Koeln-Deutz) said he had occasion to inspect powdered-coal installations and the superheating thereby produced in the cupola. When he was in America he visited a foundry where, by this method, excellent piston rings, of diameter 1 in. to 62 in., were cast from the cupola. The electric furnace was still better, for the cupola was liable to have some quenching effect.

Getting High Temperature with Powdered Coal.

CHIEF-ENGINEER KAISER (Oberhausen) said that his furnace had replaced part of the coke by powdered coal, and raised the output by 40 to 50 per cent. In fact, he had had better results from three furnaces in this way. He could not as yet give more definite data, as the furnace was now being investigated by the Kaiser-Wilhelm Iron Research Institute. He would, however, point out that he knew of a patent, granted to a Mr. A. Zenzes, which recommends adding to the iron some steel from the converter. By so doing one obtained pearlitic cast iron without fail, which showed the absurdity of Lanz's claims.

DR. LINKE (Eberswalde) said that Mr. Neubauer mentioned that Lanz has given no chemical composition for his iron in the patent specification. He fixes the sum, carbon plus silicon, at 4.2 to 4.6 per cent. Foundrymen were familiar with the diagram that gave the silicon-content as a function of the thickness of section in a casting. Using ordinary iron in the cupola one always had 3.2 per cent. carbon. If one added this to the required silicon-content for the given section it gave approximately the values cited by Lanz; but, in any case, one obtained pearlite.

CHIEF-ENGINEER GILLES (Berlin) thought that much had been said about the Patent Office, but he believed that founders are the chief culprits themselves. They had the usual time to lodge objections, but failed to do so. Lanz had a second patent covering casting at a higher temperature, which rendered it superfluous to heat the moulds before or after; but nobody lodged any objection within the stipulated period. He admitted that during that time, while the war was on, they had other things to do, but in any case they were not out to imitate the Lanz process. He had always admired the work of Diefentaeler and Sipp, and perhaps progress would not have been so far ahead to-day but for them. Nevertheless, one could admit the principle that this process should mean the closing of all other approaches to the desired end, viz., the improvement of grey cast iron.

Now that it had been proved repeatedly that to some extent even better results can be obtained than by the Lanz process, it was time that the matter should be cleared up and exaggerated claims reduced to within reasonable limits.

Catalogues Received.

Handbook for Foundrymen and Engineers.—The object of this 32-page booklet is to describe the services rendered by the laboratories and staff of Messrs. Beecroft & Partners, Limited, of St. Peter's Close, Sheffield. A number of ruled pages are provided for the noting data of the cupola, non-ferrous mixes, memoranda of tests, analyses of pig-iron and coke, and cast-iron mixtures. The dimensions of the test bars as tentatively put forward by the Institute of British Foundrymen are reproduced. A number of foundry specialities are also described.

Patents for Inventions.—With each fresh edition of the brochure issued by King's Patent Agency, Limited, of Wardrobe Chambers, 146a, Queen Victoria Street, London, E.C.4, one finds the arrangement improved and the information given more extensive. Those who have taken out patents for years often do not understand the protection afforded by their Letters Patent, whilst those who have never attempted have usually no real knowledge of the procedure and cost. The object of this booklet is completely to cover both requirements, and, as such, should commend itself to many of our readers.

Firm's Tribute to Foundryman.

The directors of H. H. Martyn & Company, Limited, and of the Gloucestershire Aircraft Company, Limited, Cheltenham, at a complimentary dinner to Mr. Arnold Edwards, the foundry manager, expressed their warm appreciation of his valued services to the firm during a period of six years. The firm used the opportunity of an accident to Mr. Edwards—whilst casting a large bronze war memorial tablet for the Commercial Bank of Sydney, Australia, which incapacitated him for some time—to pay tribute to him. This took the form of a complimentary dinner at the Lansdowne Hotel, Cheltenham, presided over by the managing director (Mr. A. W. Martyn), who handed over a substantial cheque to Mr. Edwards. It is interesting to note that Mr. Edwards has been a member of the Institute of British Foundrymen since 1908, in Manchester, Halifax, Birmingham and Cheltenham.

HAD THERE BEEN NO GENERAL STRIKE the engineering unions would by this time have been pushing forward their movement for wages increases. Fifty local applications from various parts of the country for wage advance in the engineering industry have been lodged for consideration by the central conference of the industry. Most of the applications have already been refused by the employers' side, and it is certain that the remainder will also be rejected. The offer of an extra 2s. 6d. per week which the employers made at a recent meeting of the conference is not now to be repeated.

XUM

Magnetic Separator Pulleys in Foundries.

By C. H. S. Tupholme.

During the past few years considerable improvements have been effected in the design of magnetic separator pulleys for removing magnetic material from various substances, and one of the chief directions in which the use of these pulleys has expanded is for removing iron and steel particles

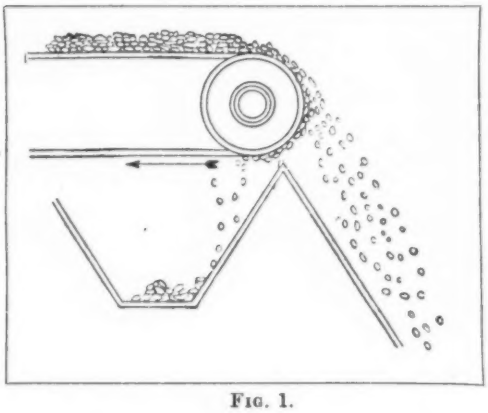


Fig. 1.

from brass and other non-ferrous metals, and also for removing metal from the sand to prevent damage to facing mixing machines.

The principle of the magnetic separator pulley is illustrated in Fig. 1, from which it is seen that as the material passes over the pulley at the end of a belt conveyor the magnetic substances adhere to the belt and are carried underneath until they are out of the magnetic field, when they drop off into a scrap bin. The sand or non-ferrous metal passes on without interruption and is discharged over the end of the belt in the ordinary way.

A typical separator pulley of up-to-date type is shown in Fig. 2, and consists of a number of steel discs keyed to a shaft, an electromagnetic winding being placed between alternate discs. The magnetising coils are wound on steel bobbins, which are dowelled to the discs to prevent shifting. The coils are all connected in series and terminal wires are brought through a hole in the centre of the shaft to a pair of collector rings, fixed far enough beyond the edge of the pulley to permit the insertion of a bearing between the collector rings and the pulleys.

The coils are impregnated with a moisture-repelling and insulating compound by the vacuum process, and the space surrounding them is filled with the same compound poured in the molten state during assembly. This ensures perfect protection from moisture, and since the compound is a better heat conductor than dead air, cooler operation of the pulley is assured. A tubular brass spacer, which also performs the function of a coil shield, is placed between adjoining steel discs. After assembly, the pulley is turned and crowned.

In judging a magnetic separator pulley it should be borne in mind that dimensions and weight are not the only features to be considered.

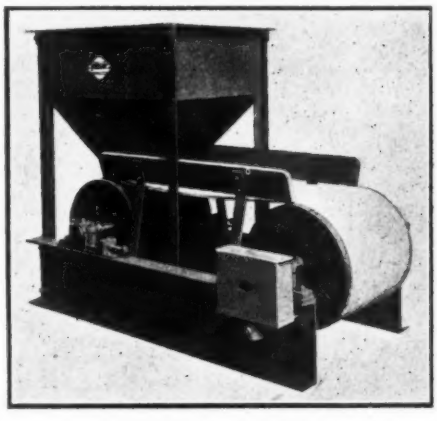


Fig. 3.

In fact, two separator pulleys of the same weight and dimensions could be made that would not be of equal efficiency. One may have less copper and more steel to secure cheaper construction, while the other, which has an abundance of copper and is not cheap, may be spoiled by a lack of steel in the magnetic circuit.

Magnetic pull varies as the square of the number of lines of force per square inch of pole area, from which it may be seen that a small reduction as from 100,000 lines per square inch to 90,000 lines per square inch reduces the pull to 81 per cent. Too much steel in the poles reduces the number of lines of force per square inch just as too little copper does.

The windings, if placed near the shaft instead of near the outside of the pulley, will require much less copper, but the efficiency will be reduced on account of excessive leakages.

The magnetising of the pulley is accomplished by means of passing direct current through windings in the interior of the pulley. The current sets up a magnetic flux, which passes through the belt and attracts any iron or steel that is carried on the belt.

Engineers should bear in mind that pulleys of large diameter will in every case give better

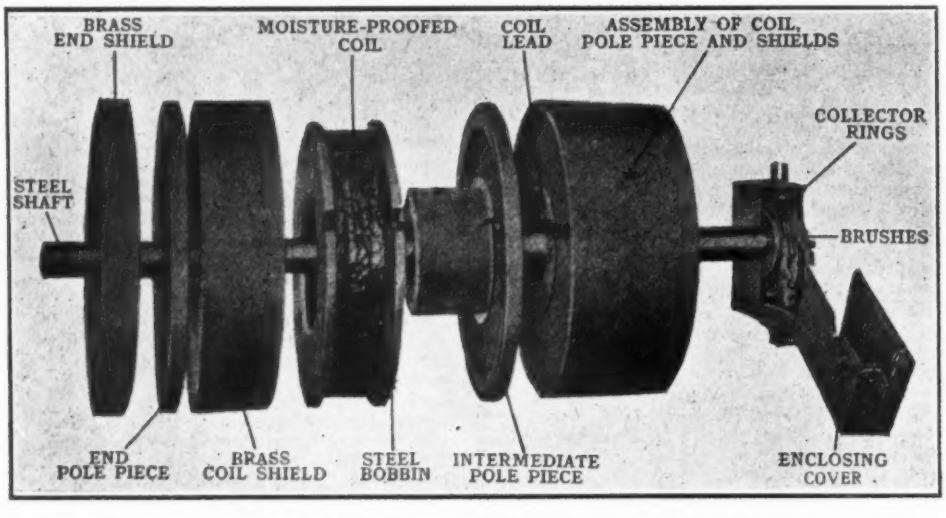


Fig. 2.—Separator Pulley Designed for Foundries.

results than those of small diameter from the standpoint of magnetic separation, and will also reduce wear and tear on the belt. Assuming the belt speed to be the same in both cases it is obvious that the rate at which the direction of motion of a piece of iron or steel is changed will be lower on the large diameter pulley than on the small one, consequently with the same intensity of magnetisation the separation accomplished by a large pulley will be better than that by a small pulley.

From the standpoint of belt life, the desirability of using a large diameter pulley is universally recognised. The pulley diameter must be large enough to give the required traction and to suit the thickness of the belt. Good practice allows 3 in. per ply; for instance, 18 in. diameter for a 6-ply belt.

Small diameter pulleys, however, are much lower in first cost, and where a short belt is used, their employment is permissible. Where conveyor flights are long, and especially where the magnetic pulley is a driving pulley for the belt conveyor system, it is frequently economical to use a large diameter pulley with a narrow face because of the saving effected in the cost of a narrow belt.

The Selling of Castings.—XXIX.

BY VOYAGEUR.

The catalogue is an extremely important factor in selling castings overseas. In a previous article the importance of obtaining competent translations has been stressed, so that further reference to this point is unnecessary. Another vital matter is the necessity of correspondence between castings and illustrations. To show photographs of castings with a good finish, well-cored holes, and clean, sharp edges is useless if, when delivered, the castings themselves are rough, full of surface flaws, or of bad appearance.

The design of the catalogue is also deserving of special consideration in the light of the special markets to be attacked. In tropical lands the intense sunlight speedily causes impermanent colours to fade, and so careful choice of papers and inks has to be made. Damp is also encountered excessively, making it imperative to choose papers specially designed to meet such conditions. Some countries have preferences for particular colours. Thus, red and orange are favourite hues in Spain, but grey, blue and brown are less popular. China regards red or gold as lucky colours. It is always advisable to follow custom in these matters, even at the expense of taste. The overseas agents will gladly supply details of idiosyncrasies of this sort, and should always be consulted before a decision is reached.

It must also be remembered that foreign postage is more expensive than home postage, and therefore excessive weight of paper should be avoided. The heavier the complete booklet, the more it will cost to distribute. In general, the kind of types chosen for overseas catalogues will need to be more open and often larger than those chiefly employed in Great Britain, since the overseas reader is not always as literate and accustomed to small type as his counterpart in England.

Circularising overseas is best carried out by the overseas agent or representative, but the manufacturer should collaborate with him to some extent. This can be done by preparing a specimen series of form-letters which the representative can modify to suit his own local conditions. The necessity for close collaboration between founder and overseas agent or branch office in all marketing plans cannot be too strongly emphasised. It is true that the founder knows more about how the castings are produced, about the goods and the difficulties their production involves, but it is equally true that the agent abroad knows more about the special needs of the market in his territory, the greater experience of foreign or colonial purchases and their demands, and closer intimacy with the technicalities of marketing in his own district. Unless both founder and agent join in the work of selling, results are unlikely to be satisfactory. Each must contribute his meed of knowledge.

This series of articles cannot cover such essentially financial and managerial matters as the choice of good agents, the allowing of credit, the organisation of branch houses, the maintenance of a staff of travelling representatives, the establishment of stocks overseas, and so on. While all these things matter in the problem of efficient overseas distribution, and therefore exercise a considerable influence on selling, they are not actually aspects of selling proper, and therefore lie outside the scope of this series. It has to be assumed that these separate problems have been satisfactorily solved before scientific selling begins. If they have not, then, of course, selling will fail to reach the highest pitch of efficiency.

At the same time, it is quite legitimate to mention the importance of keeping the overseas man in close touch with the advertising and publicity sides of the foundry business. Every time the former comes over to the head office or works he should be given a chance to make the acquaintance of the sales and publicity managers, and to talk over with them the problems of marketing, both general and special. At rough and ready meetings of this kind many points can be covered that could never be settled satisfactorily by correspondence.

Every agent and branch office abroad should have at hand for reference a full set of literature issued by the founder. This set should be kept up to date by the regular despatch of new editions or new pamphlets. This does away with the danger that the agent may quote from obsolete publications when negotiating with customers, and so cause trouble in the future. Another point to be borne in mind is that as publicity matter is not usually charged up to agents, and costs them nothing, they are apt to be either unnecessarily lavish in distributing it, or to ask for more copies than they really need, and to be less energetic than is proper in distributing them. This often means that they accumulate stocks of valuable literature that simply goes to waste. To prevent this, it is a good plan to make each agent render a yearly return of all the literature in his possession, together with the number of the edition or the date of publication. This enables the publicity manager at home to see whether the agent is wasting material and whether he is taking steps to get it into the hands of the right people.

Agents and branch offices should be advised regularly, as are home salesmen, of any facts of importance or changes concerning the castings and their performance, and of any alterations of selling plans that affect their districts. It is also advisable to give them the chance to express their opinions on such alterations before they are actually made.

One firm adopts the policy of sending to its agents a monthly letter with the intention of keeping them in close touch with home circumstances. In these letters are discussed the advertising policy, important visitors welcomed during the month, interesting orders or contracts received, useful testimonials obtained, the general state of trade, changes in management or production staff, products or departments for which more orders would be welcomed, catalogues or booklets either being reprinted or being newly designed, and so forth. The agents are thereby in a position to make speedy use of any item of information that may help them to obtain orders or promote business. Thus far it has been assumed that the founder, if represented abroad, is represented by agents or branch offices of his own; but of late years a new form of overseas selling has begun to find favour. This is the co-operative selling scheme. As this is specially important for smaller firms, the writer will discuss it fully in the next article of this series.

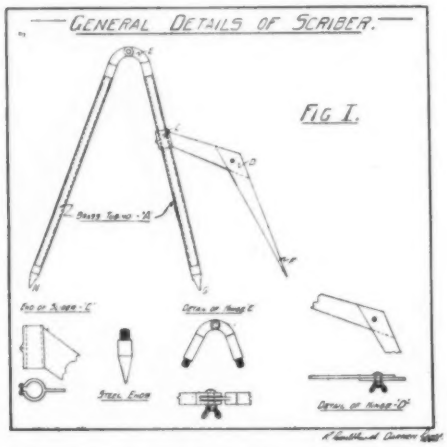
Photographing Castings and Drawings.—Panchromatic plates give excellent results for the above. This type of plate gives an intense black background and clear, well-defined lines on the exposed negative. In the case of drawings, it is advisable to use white tracing cloth instead of drawing paper. One could not wish for better results if proper care and judgment is exercised in preparing the object to be photographed. The rest, of course, relies on the skill of the camera-man.

A Scriber for Patternmakers.

BY "VALLISHE."

The patternmaker of to-day is far better equipped in regard to special tools and lathes than was his predecessor of, say, twenty years ago. Labour has been reduced to what would appear a minimum, through the introduction of efficient and high-speed machines. It would be interesting to know the origin of the design of some of our modern machines and tools.

In Fig. 1 is shown a general design of the tool, along with working details. A shows two pieces of brass tubing, ½ in. in dia., and screwed an equal distance down at each end as shown. These form the legs, and it is important that the outside surface of the tubing should be bright and normally free from rust or indentations. At the ends of each piece of tubing are two steel points screwed into the tubing. The small end of these should be practically pointed with only the sharpness taken from them. At the opposite end of the tubing is fitted a hinge of the type illustrated. The joint should be made easy, and may be tightened up by means of a wing nut, as shown. On one of the brass rods is placed a slider C. This slider should be made ⅛ in. larger in bore than the outside diameter of the brass tubing. This ensures an easy sliding action, which is the chief necessity. The back side of the slider is split



and provided with a nut and screw, so that any undue slackness that may be brought about by wear, may be easily taken up. The front side of the slider is brought out into a flat piece and shaped as shown. A small hole is drilled at the lower end to receive pricker F. It is essential that the end of the pricker should be finely pointed and that the hinge D may be nipped up tight and free from play. No definite sizes have been given for the details, as these are certainly governed by the requirements of the instrument. It is, however, improbable that the size of the tubing be required larger than ½ in. dia.

How to Use It.

Now suppose the patternmaker was required to make a sort of elliptical flange or pipe body of the dimensions 6 ins. by 10 ins. First mark off the centre and place point G (Fig. 1) on it. The other leg should be on the centre line of the greatest length (10 ins.). Move the slider round, and by adjusting the pricker, cut half the width (3 ins.). It is easily understood that if the slider leg was held perpendicular to the working plane, one turn or revolution of the slider would form a true circle. Now extend the point H. It will be found that in revolving the slider, the width (3 ins.) will remain the same, but the slider will fall as moved toward the length, thus increasing the distance from the centre. This must also be the same on the opposite side. Now extend the point H until pricker will cut the half-length (5 ins.). A correct development can now be obtained with one revolution of the slider, by pricking the path, say, in about 24 places, according to requirements.

Although this tool may not be needed every day, or maybe every week, it is surely a useful thing to keep about the shop for special jobs. Awkward curves on pipe bodies may be accurately traced out in true spherical form.

Vickers, Limited.

A statement was recently issued dealing with the reorganisation of Vickers, Limited, and confirming the report, already published in these columns, of the election of General the Hon. Sir H. A. Lawrence as chairman of the company.

The Reconstituted Management.

The report states that the reduction of capital scheme authorised by the shareholders was confirmed by order of the Court dated January 26, 1926.

The directors present a statement of the accounts for the year ended December 31, 1925. The balance of profit shown by the accounts is £420,973. Deduct preference dividends for 1925 amounting to £402,698, leaving a balance of £18,275, which has been added to the carry forward from December 31, 1924, of £172,500, leaving at credit of profit and loss account £190,775. The directors do not recommend the payment of a dividend on the ordinary shares for the year 1925.

The New Board.

Mr. W. Clark resigned his seat on the board on December 31, 1925. Since that date the resignations of the following members of the board have been accepted :—Mr. Lincoln Chandler, Mr. H. J. Morriss, Lieut.-Col. W. C. Symon, and Mr. A. Spencer.

At meetings of the company it was agreed that appointments to the board should be approved by the advisers, viz., Mr. F. Dudley Docker, the Rt. Hon. R. McKenna, and Sir William Plender, Bart., assisted by three representatives of the shareholders, viz., Sir J. Field Beale, Mr. Albert Senior, and Mr. C. E. Siddall.

In their report they unanimously recommended :—

(*a*) That a new office, to be known as president of the company, should be established, and that Mr. Douglas Vickers should be appointed first president, which office would carry with it membership of the board of directors and each of the management boards.

(*b*) That the board should be reconstituted as follows :—Chairman, General the Hon. Sir Herbert A. Lawrence; ordinary members of the board, Sir David Yule, Bart., Sir Edmund Wyldbore Smith, Mr. G. R. T. Taylor, Mr. M. Webster Jenkinson.

(*c*) That the following, who by virtue of their special knowledge will be members of one or more of the subsidiary boards, should be elected full members of the board, viz. : Sir Vincent Caillard, Sir A. Trevor Dawson, Bart., R.N., Commander C. W. Craven, R.N., Sir George Buckham, Mr. Vincent C. Vickers.

Boards of Management.

They further recommended that the following should be appointed members of the management boards :—Industrial Management Board : M. B. U. Dewar, Bernard D. F. Docker, Sir Philip A. M. Nash, W. F. Sadler, Alexander Spencer, T. L. Taylor.

Armaments and Shipbuilding Management Board : Sir George Buckham, Commander C. W. Craven, R.N., Sir A. Trevor Dawson, Bart., R.N., Oliver H. D. Vickers.

Finance Management Board : Sir Vincent Caillard, Vincent C. Vickers, A. Cartwright.

The board of directors have also, with the approval of the advisers and of the representatives of the shareholders, appointed the following members to serve on the management boards :—Industrial Management Board : Sir E. Wyldbore Smith, Sir David Yule, Bart., M. Webster Jenkinson. Armaments and Shipbuilding Management Board : George R. T. Taylor, M. Webster Jenkinson. Finance Management Board : Sir David Yule, Bart., M. Webster Jenkinson.

At the invitation of the board, Mr. F. Dudley Docker has agreed for the time being to act as an honorary member of the industrial management board, and the advisers have consented to continue to act temporarily in an advisory capacity, and to assist the Board in connection with the internal reorganisation of the company which is now in progress.

Improving Cast Iron as Shown by Tests.

In Mr. J. R. Hyde's Paper on the above, published in our last issue, we regret that in consequence of an oversight there were two errors in the table showing the results from transverse and tensile tests from various mixtures. The seventh column shows percentage of phosphorus and the eighth total carbon.

A Practical View of Facing Sands.

BY J. E. P.

As there are many kinds of moulding sands, so there are many ways of mixing them. Apparently one foundry will make quite a success by using one class of moulding sand, while another will meet with nothing but failure by using the same material. This will serve to illustrate the difference still existing in the methods of mixing the same kinds of moulding sand.

It is certainly dangerous to use a sand with a high percentage of clay in it, as a strong clayey sand, being so very close will prevent the gas passing freely through it. Also, it will cause a mould to crack very considerably, exactly as the earth's crust cracks in very dry weather. These cracks, in a loam mould especially, are a source of trouble, as in finishing a mould with cracks in it, these cracks are stopped up on the face of the mould. Behind the stopping of loam there is always a part of the cracks not filled in, so that at the time of pouring, the gas which is generated takes the least line of resistance and travels into these cracks and then pushes the stopping slightly out into the mould. This causes indentations in the casting, and these disfigurements can seldom be entirely obliterated.

There are sands on the market of a very strong nature and full of clay. These are very difficult to handle, much more so than one with far less clay in it. For moulding in dry or green sand, it is far better to obtain a sand of medium strength. All sands for moulding purposes must have a certain amount of bond in them, or they would be too friable, and would not take up the form of any pattern rammed with them. They certainly would not stand the wash of the liquid metal at the time of pouring. A really good sand for general work is one of medium strength. To determine the quality of the sand and the clay content, rub a piece of sand between the finger and thumb and if it is a good medium sand it will not leave any clay sticking to the finger or thumb. If, however, it is a strong sand with an excess of clay, the finger and thumb will leave a certain amount of clay adhering.

A medium strength sand is the best for general work, in loam, dry and green sand. With a sand of this description castings up to 4 of 5 tons in weight have been made in green sand quite successfully.

Sea shore sand or sharp sand has no bond, and is therefore useless for moulding, but it is used very extensively for coremaking.

Coal dust plays a very momentous part in moulding; when it is mixed with facing sand its real function is to create gas in so small a quantity as to form a film over the face of the mould. This prevents the metal burning the face of the mould and allows the sand to strip readily from the casting, imparting a beautiful blue skin to it.

Coal has nothing whatever to do with venting, as so many foundrymen still think. It does not convey the gas through the mould and it does not make the sand more porous as it *generates* gas. Let this at once be clearly understood and then it will be realised how very important it is to get the correct quantity of coal dust in the facing sand.

Coal dust, as its title implies, is the dust of coal, and it should be dust, not kitchen nuts, but *dust*. If there are any pieces of coal as large, or rather as small, as a pin's head in the facing sand and these pieces get to the face of the mould, the casting will be pitted and pock-marked. Sometimes it is so bad as to cause the casting to be rejected. This pitting happens more particularly in light thin castings, though it sometimes occurs in large and heavy work.

All facing sands should be thoroughly mixed. If in any batch the coal dust is in excess of the right quantity—even if it is very fine coal dust—the casting will be marked all over with lines like those on a map. This necessitates an extra amount of fettling to make the casting presentable.

It is not fully realised how vastly important the mixing of facing sand really is, or there would not be so many inconvenient slipshod fatholes (facing sand mixing departments). Where all the quantities are left in the hands of the labourer—who perhaps has no knowledge of the purpose for which the facing sand is wanted—and so long as he can keep all the moulders supplied with ample supplies of it, it is sufficient.

All sands used in facings should be properly dried and then the coal dust added. The whole of this should then be passed through a fine mesh sieve, and then the water added. Where all the sands are dried, definite instructions can easily be given, and followed out for all quantities, new sand floor or old sand and water.

If the sands are not dried then the water is applied by guess work, as the only means the mixer has to determine the quantity of water required to make the facing sand right is to keep feeling the sand until he thinks it is right.

After all the ingredients have been mixed, sifted and watered, the whole should be milled and finally put through a mechanical mixer and allowed to rest for a day or so in a moist atmosphere.

In Table I are given suitable mixtures: light work, heavy green sand, dry sand and loam.

TABLE I.—*Mixtures for various classes of Mouldings.*

	Parts by Weight.			
	Light.	Heavy Green.	Dry Sand.	Loam.
New sand (medium)	2	3½	4	4
Old sand	3	2	2	1
Coal dust	1	1½	1	—
Core gum	—	—	½	¼
Horse manure ...	—	—	—	1½

Blackings.

Blackings also have a large part to play in facing a mould. Sometimes they are mixed with the facing sand, but generally they are applied in a wet state to the loam mould, dry-sand mould and cores and dried after. In mixing blacking care should be taken to use all clean pails, so that no foreign matter can be mixed with it. A thin clay wash is used to give adhesiveness to the blacking. After mixing the blacking should stand for about 20 hours and then stirred and put through a fine mesh sieve.

Finally, it pays to buy the best of these materials from a firm of good repute. So many cheaper brands are offered which contain all sorts of impurities and never give the satisfaction that really good materials do.

Dating of Patents Committee.

A committee has been appointed by the Board of Trade to consider whether any, and, if so, what change is desirable in the practice of :—

(*a*) dating patents, applied for under Section 91 of the Patents Acts, as of the date of application in the foreign State; and

(*b*) dating patents granted upon ordinary applications as of the date of application in the United Kingdom.

The main question which the committee has to examine is whether this practice should be continued or whether patents granted upon applications made under Section 91 should bear some later date, such as the date of application in this country, or the date of grant of the patent, while still giving the applicant the priority as regards inventorship which must be given to him under international arrangements.

The committee will be glad to receive suggestions or representations upon the matters covered by their terms of reference. In considering the questions involved, the committee desires that due regard should be paid to all the interests involved, *i.e.*, the interests of inventors, manufacturers, consumers and the public generally. Communications should be addressed to the Secretary to the Committee, Mr. B. G. Crewe, the Patent Office, 25, Southampton Buildings, London, W.C.2.

Test for Water Containing Iron.—A good test to ascertain the presence of iron in water is to fill a bowl with the water to be tested and drop in a small quantity of prussiate of potash. If the water turns blue, the water contains iron.

Written Contributions to Convention Papers.

Cast Iron for Electrical Machines.

Mr. H. Field (Willenhall) wrote that he thanked the author for a very notable contribution to the literature on this subject. Many of the facts which he has noted already find application in the industry, but other parts, and especially the section on aluminium, are of the greatest interest.

It was to be regretted that some of the bars in Table I did not represent irons which were commercially practicable. Once again the use of the crucible for melting has led to the carrying out of long experiments on irons with total carbon content lower than can be obtained in commercial melting practice. This leads to a further factor in the very high combined carbon which is associated with low total carbon, for instance, in samples S 8, S 9 and S 10, there is a combined carbon more than twice as high as is obtained in practice in one-inch diameter bars with over 2.5 per cent. silicon. By this means the author is led to suggest annealing where none should be required, as the combined carbons of S 3, S 4, S 5 and S 6 can be obtained in ordinary cast metal of these silicon contents and dimensions.

In Table V, the earlier bars contain more normal total carbon, but here again the combined carbon is abnormally high, as in commercial metal with 3.4 per cent. silicon the combined carbon in practice would not exceed 0.25 per cent. If the author obtains 1.17 per cent. combined carbon in a one-inch diameter bar how would he produce machinable castings ⅛-in. thick?

It is unfortunate that such metals are chosen for a research of this kind, as they largely discount the practical value of the results obtained.

In a later paragraph of the paper the author refers to "Nomag," a patented non-magnetic cast iron, and reports that a somewhat similar alloy which he made was "hard and difficult to machine." In fairness to Messrs. Ferranti, it should be pointed out that "Nomag" is as soft as ordinary cast iron.

Under the heading, "Malleable Cast Iron," the author speciafically deals with blackheart malleable, but makes no mention of European malleable. This is rather hard on our English product, which is already having an uphill fight for existence. Actually the curve given in Fig. 16 is no better than that regularly obtained on well-annealed whiteheart malleable cast iron, which can be made almost equal in permeability to mild steel.

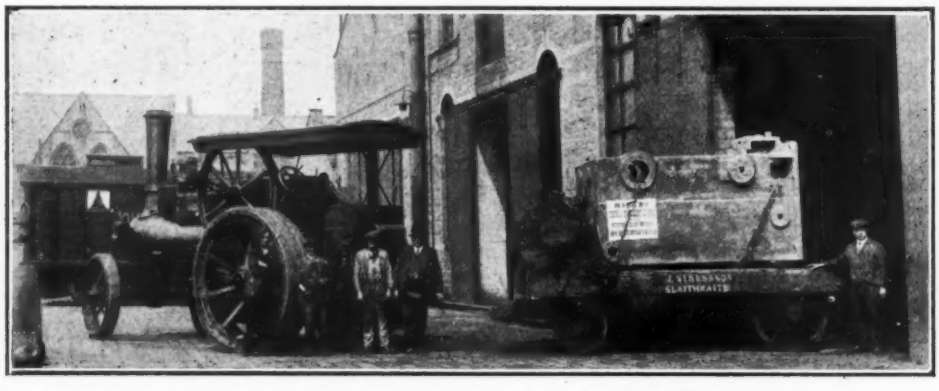
Mr. J. G. Pearce (Director, B.C.I.R.A.), wrote that doubtless some criticism will have been raised on account of the fact that the author of this paper has not dealt with cast irons, but with synthetic mixtures of a pure iron carbon alloy and the various elements, the influence of which he desired to determine. From this point of view the title of the paper will appear misleading.

In dealing, however, with such an alloy as cast iron, it is necessary to make such preliminary tests, but it is equally important that they should be produced and treated in a commercial way, particularly when dealing with the influence of the addition of special elements. It is at this stage in a piece of work of this character at which the Cast Iron Research Association should consider completing the work, and this matter is under consideration.

Results Obtained in the Improvement of the Qualities of Cast Iron.

Mr. J. G. Pearce (Director, B.C.I.R.A.) wrote that he suggested that it would be advantageous if the author would give in greater detail the construction and use of the diagram prepared some years ago by M. Portevin. This diagram is not at all well known to British readers.

It is perhaps necessary to bear in mind that a complex system like cast iron contains so many constituents that it can never be completely represented on a diagram. Such diagrams may conveniently be considered as a means of comparing one iron with another, and constitute a kind of metallurgical shorthand. Apart from composition, the properties of grey iron are governed by the rate of cooling. This factor is not taken into account in any of the diagrams mentioned by the author. He does not refer to a recent attempt to take this factor into account by Greiner and Klingenstein, whose diagram from the Gusseisen-Taschenbuch, 1926, is reproduced on page 18 of the Cast Iron Research Association's Bulletin. In this case the sum of carbon and silicon is plotted against thickness, and is compiled for cupola-melted metal having a total carbon content not less than 2.8 per cent. The diagram shows, for example, that an iron containing 3.2 per cent. carbon and 1.8 per cent. silicon would be white if cast ⅛-in. thick, while ⅛-in. to 3-10th in. would give a mottled iron. Beyond this, to 1.1 in. thickness it would be pearlitic, and above 1.18 in. thickness free ferrite would appear in the structure, increasing in quantity as the thickness increases. When such diagrams are published it is highly desirable that those founders who have access to results, including analyses and micros, going back over a period of years should test their previous results against the diagram and see whether the diagram is reasonably correct.



A LARGE BODY CASTING LEAVING THE FOUNDRY OF THOS. BROADBENT & SONS, LIMITED, HUDDERSFIELD. THE WEIGHT WHEN CAST WAS 15 TONS 17 CWTS. 1 QR., AND WHEN FETTLED 14 TONS 7 CWTS. 1 QR.

Iron and Steel Output in June.

The National Federation of Iron and Steel Manufacturers report that on the eve of the coal stoppage 147 blast furnaces were in operation. These were reduced to 23 by the end of May, and still further reduced to 11 by the end of June. The production of pig-iron in June amounted to 41,800 tons, compared with 88,800 tons in May, 539,100 tons in April and 510,300 tons in June, 1925. Production of steel ingots and castings in June amounted to 32,800 tons, compared with 45,700 tons in May, 661,000 tons in April and 585,400 tons in June, 1925.

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Messrs. Thomas Wilkinson & Co., Ltd., Stockton Street, Middlesbrough.

LONDON:
Messrs. The Blackfriars Foundry Requisite Co., Ltd., 34/35, Norfolk Street, London, W.C.2.

GLASGOW:
Messrs. Albert Smith & Co., Foundry Engineers, etc., 60, St. Enoch Square, Glasgow.

Trade Talk.

THE mills at the Ebbw Vale Works were restarted last week.

A NEW semi-continuous bar and rod mill, to operate in conjunction with the continuous hoop and strip mill at the Newport Works of the Whitehead Iron and Steel Company, Limited, will go into commission next month. This will effect a considerable reduction in costs and increase in output.

THE two-monthly ascertainment of the price of West Coast hematite pig-iron mixed numbers shows that there was a rise in value of 1s. 2¾d. to £3 16s. 6.37d per ton. In accordance with the agreement of October 21, 1925, the sliding scale percentage of base rates and tonnage rates will remain unaltered at 10 per cent.

THE ELECTRIC CONSTRUCTION COMPANY, LIMITED, of Wolverhampton, have acquired the electrical business of Sandycroft, Limited. Mr. L. J. Hunt, 4, Broad Street Place, London, E.C.2, has entered into an agreement with the Electric Construction Company to act in a consulting capacity to them for the design and sales of Cascade induction and synchronous motors and self-paralleling alternators.

CAMMELL, LAIRD & COMPANY, LIMITED, Nottingham, have received an order from the London and North-Eastern Railway Company for two additional Sentinel-Cammell coaches and thirty-four all-steel luggage brake vans. Cammell, Laird & Company's associated concern, the Midland Railway-Carriage & Wagon Company, Limited, Birmingham, have also received an order from the L. & N.E. Railway for four articulated trains, comprising thirty-two coaches in all.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, Trafford Park, Manchester, recently have introduced an improved phase advancer, the principle of which is based on the phase advancer designed for the Metropolitan-Vickers Company by Prof. Miles Walker, about 16 years ago; but important improvements have made possible a greatly simplified construction, resulting in lower first cost and maintenance expenses, greater reliability, and better operating characteristics.

THE PNEULEC MACHINE COMPANY, LIMITED, Mafeking Road, Smethwick, near Birmingham, have an order from the Coalbrookdale Company, Limited, Coalbrookdale, Salop, for a complete melting plant, in which is included two 7 ft. 6 in. diameter cupolas. In addition, the company have, in the past fortnight, received cupola orders from Rice & Company (Northampton), Limited, Northampton; the Alliance Foundry Company, Limited, Luton, and J. and J. Siddons, Limited, West Bromwich. Two separate orders for sand drying equipment have also been received, both machines having a capacity of two tons per hour.

NEWTON, CHAMBERS & COMPANY, LIMITED, Thorncliffe Ironworks, near Sheffield, have acquired the sole patent rights of the Hurst-Ball centrifugal casting process and the plant for the production of casting by this process from Centrifugal Castings, Limited, Kilmarnock. The company have inaugurated the Thorncliffe Centrifugal Castings Department in their works to continue the manufacture and supply of standard castings for piston rings of all sizes up to 48 in. diameter, and also special castings for cylinder liners, sleeve valve liners and other similar castings by the centrifugal process. The plant is now in the course of re-erection, and very shortly it is expected that it will be ready for production.

Obituary.

MR. A. G. CHARLETON, a past president of the Institute of Mining and Metallurgy, of 5, Avonmore Road, London, W.14, died suddenly on July 7, while on a visit to France.

MR. C. S. GILMAN, chairman of Allen-Liversidge, Limited, died suddenly on July 4. Mr. Gilman was also a director of the Westminster Electric Supply Corporation and of the Central Electric Company.

MR. J. THOMAS, one of the pioneers of the steel-casting industry, died at his residence, Dilkusha, Cyncoed Avenue, Penylan, Cardiff, on July 8. Mr. Thomas was manager of the Dowlais-Cardiff Works from 1897 until his retirement in 1920. A native of Pembrokeshire, he gained his early experience of the steel industry at Landore, and then proceeded to the Newton Steelworks at Glasgow. Fifty-two years ago he returned to South Wales and assisted the late Mr. Isaac Butler in starting the Panteg Steelworks, subsequently returning to Glasgow as manager of the steelworks there, and being the first man to undertake steel-casting in Scotland. He also introduced the the casting of steel at Barrow-in-Furness when there as works manager, while he was largely responsible for the success achieved by the steel department at the Dowlais-Cardiff Works in the years when he was manager. Seventy-six years of age he was one of the oldest members of the steel trade in South Wales.

Contracts Open.

Fort William, July 24.—Tank, with extensions of 9-in. cast-iron water main, for the Town Council. The Burgh Surveyor, Cameron Square, Fort William.

Greenock, July 31.—Filter, supplying, laying, and jointing cast-iron pipes, valves, special castings, etc., for the Greenock P.C. G. R. Blake, the engineer, 88, Great Clyde Street, Glasgow. (Fee, £1 1s., returnable.)

Lockwood, Huddersfield.—35 to 40 tons of constructional steelwork. Messrs. D. Brown & Sons (Huddersfield), Limited, Park Works, Lockwood.

Pontefract, July 27.—50 tons of 4-in. diameter cast-iron pipes, for the Corporation. Mr. W. H. Newton, borough engineer and surveyor, Municipal Offices, Pontefract.

New Companies.

Mahler & Company (Liverpool), Limited, 701, Royal Liver Building, Liverpool.—Capital £2,100 (1,000 "A" and 1,100 "B" ordinary). Iron and steel merchants, etc. Directors: W. H. Jones and W. D. Peet.

Starkie & Sparkes, Limited.—Capital £1,000 in £1 shares. Electrical engineers. Directors: E. Starkie, 17, Osborne Road, Oldham; F. Sparkes, 330, Park Road, Oldham.

Willbloom, Limited, 38, Bishop Street, Birmingham.—Capital £1,000 in £1 shares. Copper smiths. Directors: A. E. Williams, Wethersfield, Station Road, Knowle; F. C. M. Bloomer, 6, Talbot Road, Street Lane, Roundhay, Leeds.

Wire Wheel Company, Limited, 25-7, Oxford Street, W.1.—Capital £1,000 in £1 shares. Directors: E. W. Evans, D. H. Harrington, and C. A. Austin.

Yorkshire Repetition Castings Company, Limited.—Capital £5,000. Permanent directors: W., 71, Parkside Road, Bradford, and W. G. Thornton and G. A. B. Lockley.

Company Reports.

Steel Developments, Limited.—Half-yearly dividend, 3 per cent., less tax.

Baldwins, Limited.—Payment of final dividend on both classes of preference shares passed.

Darlington Forge Company, Limited.—Loss for year, £57,697; debit balance brought in, £132,521; total debit, £190,218, carried forward.

National Smelting Company, Limited.—Profit, £277,371; net revenue, £99,261; brought forward, £23,389; total credit balance, £122,650; dividend on preference shares to December 31, 1925, £52,000; carried forward, £70,650.

Whitehead Iron and Steel Company, Limited.—Net profit for year, £43,063; interim dividend, 6 per cent. (actual), less tax; to depreciation reserve, £15,000; general reserve, £10,000; final dividend, 7½ per cent., making 13½ per cent. (actual), less tax, for year; carried forward, £5,039.

Mirrlees, Bickerton and Day, Limited.—Net profit, £17,732; brought forward, £7,033; total, £24,765; dividend on preference, 5½ per cent., £1,562; final preference dividend, 5½ per cent. per annum, less tax; payment of Dominion income-tax recovered on preference share dividends, £397; carried forward, £21,244.

Law Report.

Rotherham Union Assessment Committee *v.* William Griffiths & Sons, Limited.

At the Rotherham Quarter Sessions, recently, Mr. H. R. Bramley, appearing for the Rotherham Union Assessment Committee, asked that the award of the Recorder, who had acted in the rating arbitration of William Griffiths & Sons, Limited, spring manufacturers, of Blackburn Meadows, Rotherham, should be recorded as an order of the court. Mr. Bramley said Messrs. Griffiths appealed against the assessment of £750. When the appeal came before the Quarter Sessions on April 16 last it was referred to the Recorder with full power to determine the same as arbitrator. The arbitration was held in London on June 8 and 9 last, and the arbitrator decided that the rateable value was correct. The appeal was therefore dismissed, appellants paying the respondents the costs of the appeal.

The Recorder made the order asked for.

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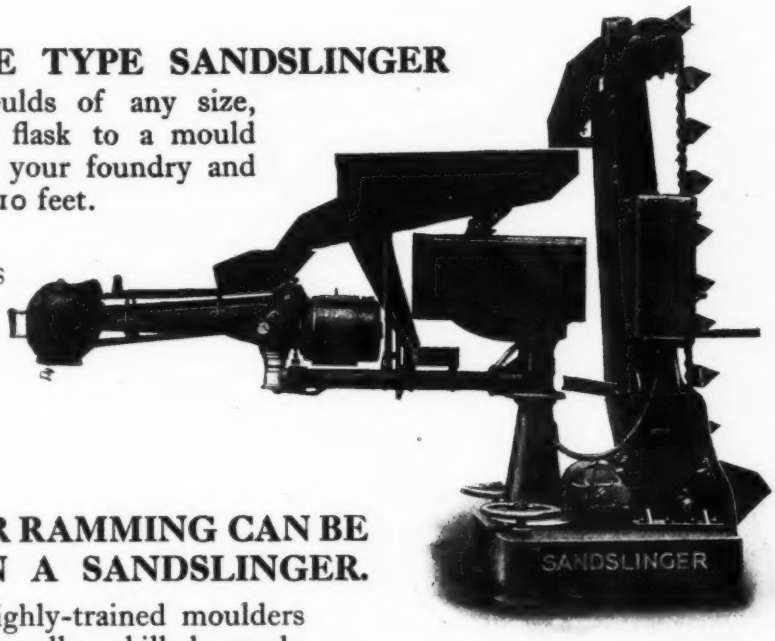

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Greensand and Drysand moulds are being rammed by Sandslingers and producing castings correct to pattern size.

Sandslingers are producing castings up to 40 tons.

ECONOMY.	Floor Space.	Two to three castings are being made on the same floor space required for one hand moulded.
ECONOMY.	Time.	Riddling, filling and ramming in one operation at 5 to 10 cub. ft. of sand per minute.
ECONOMY.	Cost.	Sandslingers are ramming up jobbing moulds in minutes compared with hours by hand ramming.

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—In this critical period of the nation's industrial history it is, at all events, subject for congratulation that there have been no signs of anything approaching panic conditions in the iron markets of the country, and in Tees-side especially the position has been met with philosophic calmness, although the stringency has become weekly more acute. The steady depletion of stocks consequent upon the closing down of furnace outputs has now almost reached the vanishing point, while the price of No. 3 quality pig has steadily advanced, with the figure now soaring to near wartime levels. Notwithstanding these difficulties, there are still buyers at current high figures, although certainly the demand is slackening, this being due apparently to the completion of work in hand at some of the foundries, and the difficulty of obtaining further orders. Pig-iron prices at the moment stand as follow :—No. 1, 90s. 6d. per ton; No. 3, G.M.B., 87s. 6d.; No. 4 foundry, 86s. 6d.; and No. 4 forge, 86s. per ton.

In the hematite section stocks are still available for supplies, with prices steadily maintained at about previous quotations, East Coast mixed numbers ruling at round 90s. per ton, with 6d. per ton extra for the No. 1 quality. On the North-West Coast Bessemer mixed numbers are quoted at £4 4s. per ton, c.i.f. Welsh ports; about £4 7s. 6d. per ton, delivered at Glasgow; £4 9s. 6d. to £4 11s. 6d. per ton, delivered at Sheffield; and round £4 17s. 6d. per ton, delivered at Birmingham.

LANCASHIRE.—There is now very little foundry pig on offer at the local markets, most of the Midland furnaces being out of commission, Scottish brands having been about the only variety that has been available for some weeks, and even this has about come to an end, for quotations for early delivery have been withdrawn altogether. For forward delivery, Scottish makers of No. 3 foundry pig are quoting at from 100s. to 101s. per ton, delivered Manchester or equal, but there is little or no demand for it.

THE MIDLANDS.—Similar stringent conditions to those previously noted are now in evidence in this district, but there is a little all mine iron being offered from local furnaces at about £5 2s. 6d. per ton, delivered Birmingham stations or equal. Nothing is coming from Derbyshire or Northants. furnaces, apart from small quantities of close pigs or forge iron; the former is quoted at about 70s. at the furnaces, and No. 4 foundry at 90s. f.o.t.

SCOTLAND.—The annual summer holidays having commenced in the Clydeside area, markets are practically suspended for the next two or three weeks. Meantime, prices continue to rise, and, whilst the lowest quotation for No. 3 Scotch foundry is 82s. 6d. per ton, f.o.t. furnaces, as high as 87s. is being asked for some irons.

Finished Iron.

Manufacturing operations everywhere having been curtailed or entirely suspended, the only material now available appears to be from stocks held by merchants, and, of course, there is not very much of that to be had after a coal strike lasting eleven weeks. It is reported that there are no Staffordshire ironworks now in operation. Lancashire continues to produce a little rolled iron to meet the requirements of old customers, and the price, of course, is advanced in conformity with the prevailing conditions. There is some demand for structural steel, but, unfortunately, such as is available is mostly of foreign origin. There are reports of increased demand, but probably the search for supplies by sending out inquiries broadcast magnifies the apparent demand in a way that would not occur if all the customary producers were at work.

Steel.

In the absence of any signs of improvement in the matter of fuel supplies, the position in the steel industry discloses increasing difficulty in maintaining production of ordinary qualities of material, but where expenditure on imported coal, amounting to anything up to 55s. per ton, is justified, the output of high-class steel on a small scale has been resumed. A good many inquiries are about, but the difficulty of quoting, and guaranteeing delivery at a date, of course, retards the placing of orders. The general tone, however, continues good, and if the strike does not drag on—and there is a growing expectation that it will not last much longer—there is strong hope of an early revival in all steel business.

Scrap.

As only a limited number of foundries is now fully employed, the demand for scrap material is necessarily on a diminished scale, and markets are consequently idle. In the prevailing conditions, prices are difficult to estimate, but the following current quotations at Glasgow may about indicate the trend of market values in general, including delivery, f.o.t. consumers' works:—Heavy steel scrap, 65s.; ditto basic, 60s.; hydraulically compressed steel shearings, 62s. 6d.; ditto, second quality, 60s.; turnings, 50s. to 52s. 6d.; C.I. borings, 48s. 6d.; machinery C.I., 75s.; heavy ordinary C.I., 70s.; old C.I. railway chairs, 74s.; light C.I. and firebars, 59s.

Metals.

Copper.—Notwithstanding the temporary depression now prevailing in most of the metal consuming industries, the tone of the market for standard copper remains remarkably firm, with values generally indicating a steady upward tendency. The report that the American copper export trading companies' scheme will not come into operation for another month was a matter of disappointment to bull operators in the copper market, and this explains the slowing down of speculative operations. Forward offerings, however, have been kept in narrow compass. Very little second-hand copper is available, and, generally speaking, there appears to be a scarcity of nearby electro.

Official closing prices of standard copper have been as follows :—

Cash: Thursday, £58 5s.; Friday, £58; Monday, £57 17s. 6d.; Tuesday, £57 17s. 6d.; Wednesday, £57 15s.

Three Months: Thursday, £59 2s. 6d.; Friday, £58 15s.; Monday, £58 12s. 6d.; Tuesday, £58 12s. 6d.; Wednesday, £58 10s.

Tin.—A marked feature in this section of the metal markets has been an active buying movement from America, which, in conjunction with a more favourable statistical position, has stimulated sharp upward fluctuations in values. It is, moreover, evident that the world's current production is being easily absorbed, in spite of the temporary curtailment of home consumption due to the coal crisis. The outlook for the current month is also considered good, with Straits shipments provisionally estimated at about 5,300 tons and the prospect of continued large American deliveries.

Official closing prices of standard tin have been as under :—

Cash: Thursday, £280 5s.; Friday, £280 10s.; Monday, £282 10s.; Tuesday, £285; Wednesday, £285 2s. 6d.

Three Months: Thursday, £280; Friday, £280; Monday, £281; Tuesday, £282 15s.; Wednesday, £282 10s.

Spelter.—Values of this metal continue firm, with a steadily advancing tendency both at home and abroad. Industrial conditions on the Continent are now much better, due no doubt to the general paralysis in Great Britain, and the consumption of zinc is considerably greater. It is doubtful whether the rolling trade on the Continent was ever busier than is the case to-day; there is hardly a mill to-day which can book fresh orders for sheet zinc for delivery earlier than two months.

The following are the week's prices :—

Ordinary: Thursday, £34 5s.; Friday, £34; Monday, £33 17s. 6d.; Tuesday, £34; Wednesday, £33 18s. 9d.

Lead.—The firmness of the market for soft foreign pig and the upward move in values are apparently not due so much to an improved trade demand as the large purchases on French account against further declines in the exchange. This is giving an appearance of strength to the market which is not supported by the general situation. Confidence in the future is lacking, and while consumption on the part of the trade is poorer, production is apparently being maintained at a high level.

The week's prices are appended :—

Soft foreign (prompt): Thursday, £31 17s. 6d.; Friday, £32; Monday, £32 2s. 6d.; Tuesday, £32 11s. 3d.; Wednesday, £32 10s.

Death of Mr. Percy Stubbs.

We regret to announce the death of Mr. Percy Stubbs, a director of Joseph Stubbs, Limited, Mill Street Works, Ancoats, Manchester, which occurred on July 7 after a short illness.

OEHM'S

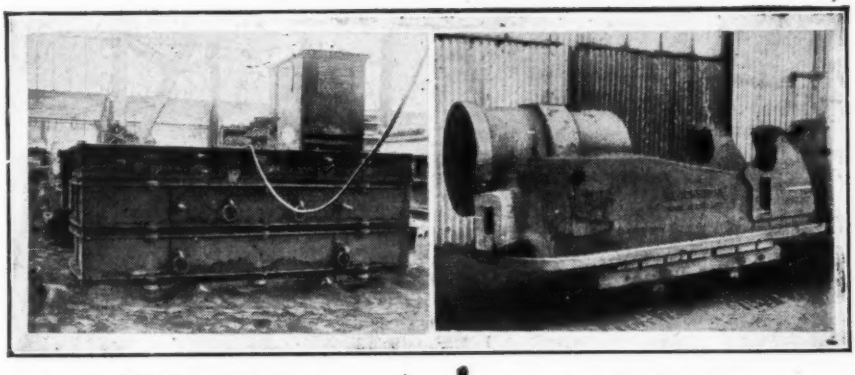
PATENT

HEATING ELEMENTS

(ENTIRELY BRITISH MADE)

HALVE YOUR FUEL BILL

The application of Oehm's Patent Heating Element results in a 50% saving in fuel consumption, and the cheapest form of fuel—hard coke, breeze and even refuse—can be used. It works twice as quickly as any other method and its use in mould drying results in a BETTER CASTING.



Medium size OEHM'S Heating Element in operation on an Engine Bed Mould in Messrs. Blackstones' Foundry at Stamford.

Above illustration showing the Resultant Casting.

The OEHM'S Patent Heating Element is the simplest and the most efficient apparatus yet devised for producing high temperatures by the conversion of solid fuel to CO_2 gas, possessing pressure and velocity without flame and without smoke.

For Core and Mould drying on the floor, in Pit or Drying Rooms. For Heating Ladles, Shanks, Ingots, etc. For Annealing and all Heat Treatments.

Write for illustrated booklet.

CONSTRUCTED BY

BRITISH DRYING & HEATING Co., Ltd.,

433, ABBEY HOUSE, VICTORIA STREET, LONDON, S.W.1

Telephone: Victoria 2693. *Telegrams: "Britdriet, Sowest, London."*

BRITISH D&H COMPANY LTD

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	57	15	0
Three months	58	10	0
Electrolytic	65	10	0
Tough	63	5	0
Best selected	63	15	0
Sheets	90	0	0
India	74	0	0
Wire bars	65	15	0
Do. August	65	15	0
Do. Sept.	65	17	6
Ingot bars	65	15	0
H.C. wire rods	69	15	0
Off. av. cash, June	56	16	9 9/11
Do., 3 mths. June	57	14	1 1/11
Do., Sttlmnt, June	56	17	1 10/11
Do., Electro, June	64	16	7 1/11
Do., B.S., June	62	4	2
Aver. spot price copper, June	56	17	2
Do., wire bars, June	65	11	4½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlkd.	7½d.
Sheets to 10 w.g	10½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	285	2	6
Three months	282	10	0
English	284	0	0
Bars	285	10	0
Straits	294	0	0
Australian	—		
Eastern	290	12	6
Bancа	297	0	0
Off. avr. cash, June	268	9	5 19/20
Do., 3 mths., June	267	13	0 3/20
Do., Sttlmt. June	268	8	7 7/11
Aver. spot., June	268	9	6

SPELTER.

	£	s.	d.
Ordinary	33	18	9
Remelted	33	10	0
Hard	29	0	0
Electro 99.9	37	5	0
English	34	12	6
India	31	10	0
Zinc dust	42	0	0
Zinc ashes	15	0	0
Off. aver., June	33	6	5 1/22
Aver., spot, June	33	4	10½

LEAD.

	£	s.	d.
Soft foreign ppt.	32	10	0
English	33	15	0
Off. average, June	30	1	3 15/22
Average spot, June	29	19	8½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	42	0	0
Do. V.M. ex whf.	39	0	0
Rods	44	0	0
Boiler plates	38	10	0
Battery plates	38	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	74	10	0
Chinese	61	0	0
Crude	40	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	15	7	6

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon 25%	9	0	0
45/50%	11	5	0
75%	19	10	0
Ferro-vanadium— 35/40%	15/- lb. va.		
Ferro-molybdenum— 70/75% c. free	5/9 lb.		
Ferro-titanium— 23/25% carbonless	11½d.		
Ferro-phosphorus, 20/25%,	£17	0	0
Ferro-tungsten— 80/85%, c.fr.	1/4½ lb.		
Tungsten metal powder— 98/99%	1/10½ lb.		
Ferro-chrome— 2/4% car.	£33	10	0
4/6% car.	£22	0	0
6/8% car.	£21	10	0
8/10% car.	£20	15	0
Ferro-chrome— Max. 2% car.	£37	0	0
Max. 1% car.	£43	10	0
Max. 0.70% car.	£54	10	0
70%, carbonless	1/5½ lb.		
Nickel—99%, cubes or pellets	£170		
Cobalt metal—98/99%	10/- lb.		
Aluminium 98/99%	£118		
Metallic Chromium— 96/98%	3/3 lb.		
Ferro-manganese (net)— 76/80%, loose	£15	0	0
76/80%, packed	£16	0	0
76/80%, export	£14	5	0
Metallic manganese— 94/96%, carbonless	2/- lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	2	6
Finished bars, 18% tungsten	3	0

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. and over .. 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Do. under ¼in. to ⅛ in. .. .. 1/- lb.
Flats, ½in. × ½in. to under 1 in. × ⅛ in. 3d. lb.
Do. under ½in. × ½in. 1/- lb
Bevels of approved sizes and sections 6d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces .. .. 3d.
Turnings and swarf 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	3	5	0 to	3	7	6
Bundled steel & shrngs.	3	3	0 to	3	6	0
Mixed iron & steel	3	0	0			
Heavy cast iron	3	0	0			
Good machinery for foundries	3	5	0			
Cleveland—						
Heavy steel	3	1	0			
Steel turnings	2	6	0			
Cast iron borings	2	5	0			
Heavy forge	4	2	6			
Bushelled scrap	3	10	0			
Cast-iron scrap	3	8	6			
Lancashire—						
Cast-iron scrap	3	2	6 to	3	10	0
Hvy. wrought	3	2	6			
Steel turnings	2	2	0			

London — Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	48	0	0
Brass (clean)	39	0	0
Lead (less usual draft)	27	0	0
Tea lead	22	0	0
Zinc	22	0	0
New aluminium cuttings	80	0	0
Braziery copper	44	0	0
Gunmetal	45	0	0
Hollow pewter	185	0	0
Shaped black pewter	135	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast—
Foundry No. 1 .. 90/6
Foundry No. 3 .. 87/6
Foundry No. 4 .. 86/6
Forge No. 4 .. .. 86/-
Hematite No. 1 .. 80/6
Hematite M/Nos. .. 80/-

N.W. Coast—
Hem. M/Nos. d/d Glas. 87/6
„ d/d Birm. 97/6

Midlands—
Staffs common* .. —
„ No. 4 forge .. —
„ No. 3 foundry —
Shrops. basic .. .. —
„ Cold blast, ord.* —
„ „ roll iron* .. —
* d/d Birmingham.

Northants forge .. .. —
„ fdry No. 3 .. —

Derbyshire forge .. —
„ fdry. No. 3 .. —
„ basic .. .. .. —

Scotland—
Foundry No. 1 .. 90/-
„ No. 3 .. 85/-
Hem. M/Nos. 79/-

Sheffield (d/d district)—
Derby forge .. .. —
„ fdry. No. 3 .. —
Lincs. forge .. .. —
„ fdry. No. 3 .. —
E.C. hematite 91/6
W.C. hematite .. 90/6

Lincs. (at furnaces)—
Forge No. 4 .. .. —
Foundry No. 3 .. .. —
Basic .. .. .. —

Lancashire (d/d eq. Man.)—
Derby forge .. .. —
„ fdry. No. 2 .. —
Northants foundry No. 3 .. .. .. —
Dalzell, No. 3 .. .. —
Summerlee, No. 3 .. —
Glengarnock, No. 3 .. —
Gartsherrie, No. 3 .. —
Monkland No. 3 .. .. —
Coltness, No. 3 .. .. —
Shotts, No. 3 .. .. —

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron— Bars (cr.)	11	5	0 to	12	0	0
Angles			..	11	10	0
Tees to 3 united ins.			..	12	0	0
Nut and bolt	10	5	0 to	10	7	6
Hoops	14	0	0 to	15	0	0
Marked bars (Staffs.) f.o.t.			..	14	0	0
Gas strip			..	12	10	0
Bolts and nuts ⅜ in. × 4 in.			..	15	5	0
Steel— Ship plates			..	8	2	6
Boiler plts.			..	11	5	0
Chequer plts.			..	10	0	0
Angles			..	7	7	6
Tees			..	8	7	6
Joists			..	7	7	6
Rounds and Squares 3 in. to 5½ ins.			..	8	0	0
Rounds under 3 in. to ⅜ in.			..	7	15	0
Flats, over 5 in. wide and up			..	8	10	0
Flats, 5in. to 1½in.				7	10	0
Rails, heavy			..	8	0	0
Fishplates			..	12	0	0
Hoops (Staffs.)			..	10	10	0
Black sheets, 24g.				11	2	6
Galv. cor. sheets, 24g.			..	17	0	0
Galv. fencing wire 8g. plain				13	0	0
Billets, soft			..	6	10	0
Billets, hard			..	8	2	6
Sheet bars			..	6	5	0
Tin bars d/d			..	6	5	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3½
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

Per lb.
Ingots for raising 9d. to 1/3
Rolled—
To 9 in. wide 1/3 to 1/9
To 12 in. wide 1/3½ to 1/9½
To 15 in. wide 1/3½ to 1/9½
To 18 in. wide 1/4 to 1/10
To 21 in. wide 1/4½ to 1/10½
To 25 in. wide 1/5 to 1/11
Ingots for spoons and forks .. 9d. to 1/5½
Ingots rolled to spoon size .. 1/- to 1/8½
Wire round— 3/0 to 10 G. 1/6½ to 2/1½
with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated. Dols.

No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	19.76
No. 2 foundry, Birm.	21.00
Basic	19.76
Bessemer	20.76
Malleable	19.51
Grey forge	19.01
Ferro-mang. 80% d/d	88.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	36.00
Wire rods	45.00

Cents.

Iron bars, Phila.	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.50
Sheets, black, No. 28	3.10
Sheets, galv., No. 28	4.25
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
„ furnace	—
Durham & North. foundry	—
„ furnace	—
Other Districts, foundry	—
„ „ furnace (basis)	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20×14, box		26/-
„	28×20, „	52/-
„	20×10, „	—
„	18¾×14, „	—
C.W.	20×14, „	24/-
„	28×20, „	—
„	20×10, „	—
„	18¾×14, „	—

Terneplates 28×20, — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£18/10 to £19/0
Rolled Ord.	£15/10/0 to £16
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12
Pig-iron	£6 5 0 to £7 0 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas ..	60%	.. 50%
Water ..	55%	.. 45%
Steam ..	50%	.. 40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
July 15	58	5	0	No change
,, 16	58	0	0	dec. 5/0
,, 19	57	17	6	,, 2/6
,, 20	57	17	6	No change
,, 21	57	15	0	dec. 2/6

Electrolytic Copper.

	£	s.	d.	
July 15	66	0	0	No change
,, 16	66	0	0	,, ,,
,, 19	65	10	0	dec. 10/-
,, 20	65	10	0	No change
,, 21	65	10	0	,, ,,

Standard Tin (Cash).

	£	s.	d.	
July 15	280	5	0	dec. 5/-
,, 16	280	10	0	inc. 5/-
,, 19	282	10	0	,, 40/-
,, 20	285	0	0	inc. 50/-
,, 21	285	2	6	inc. 2/6

Tin (English ingots).

	£	s.	d.	
July 15	278	15	0	inc 5/-
,, 16	279	0	0	,, 5/-
,, 19	281	0	0	,, 40/-
,, 20	284	0	0	inc. 60/-
,, 21	284	0	0	No change

Zinc Sheets (English).

	£	s.	d.	
July 15	42	0	0	No change
,, 16	42	0	0	,, ,,
,, 19	42	0	0	,, ,,
,, 20	42	0	0	,, ,,
,, 21	42	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
July 15	34	5	0	dec. 2/6
,, 16	34	0	0	,, 5/-
,, 19	33	17	6	,, 2/6
,, 20	34	0	0	inc. 2/6
,, 21	33	18	9	dec. 1/3

Lead (English).

	£	s.	d.	
July 15	33	0	0	No change
,, 16	33	5	0	inc. 5/-
,, 19	33	5	0	Nochange
,, 20	33	15	0	inc. 10/-
,, 21	33	15	0	No change

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	—	—	—	—	—	7 2 10½

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